JUN 2 1926

MECHANICAL ENGINEERING

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G. B. Wharen

F. W. Kouwenhoven

T. P. Gates

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N. E. Funk

A. H. Markwart

Contributors to this Issue

Arthur H. Markwart has been associated with the engineering activities of the Pacific Coast for a great many years. As a member of the firm of Galloway & Markwart, consulting engineers, from 1906 to 1920, he was identified with many of the hydraulic and civil engineering projects for private interests and also for the Federal Government. He was appointed chief of construction of the Panama-Pacific Exposition, and not only held that office but also the position of assistant director of works. In 1922 Mr. Markwart was appointed vice-president in charge of engineering of the Pacific Gas & Electric Co. of San Francisco, in which capacity he has charge of the designing and planning of all construction. He is a member of the American Society of Civil Engineers.

* * * * *

Nevin E. Funk was born in Bloomsburg, Pa., was graduated as an electrical engineer from Lehigh University in 1905, and served as an apprentice with the Westinghouse Electric Manufacturing Co., and as assistant professor at the Georgia School of Technology, Atlanta, during the next two years. Since then he has been with the Philadelphia Electric Company in various capacities from assistant foreman of electrical construction to his present position of operating engineer.

* * * * *

M. K. Bryan was graduated from the mechanical engineering course of the University of Pennsylvania in 1910, and then for two years served as an instructor there. In 1912 he became connected with the Pittsburgh Valve, Foundry & Construction Co., and the following year with the American Sheet & Tin Plate Co. in power-plant betterment work. From 1916 to 1922 he was associated with John A. Stevens, consulting engineer, and since that time has been with Chas. T. Main, Engineer, Boston. Mr. Bryan is secretary of the Boston Section of the A.S.M.E.

* * * * *

Ernest W. Dichman was graduated from the University of California in 1914 and was subsequently connected with the Pacific Gas & Electric Co., the U. S. Naval Radio Laboratory at Mare Island, Cal., and the General Electric Co., Schenectady, N. Y. He entered the service of the United States in 1917 as a flying cadet, and was commissioned a second lieutenant in the Signal Reserve Corps in 1918. He went to France in October, 1918, to secure technical information, and returned three months later, reporting at McCook Field, where he held various positions with the Engineering Division. In 1924 he was transferred to Kelly Field for duty with troops, remaining until March of this year, when he returned to McCook Field and now occupies the position of Chief of Airplane Section, holding a commission as first lieutenant.

* * * * *

Thayer P. Gates is a consulting engineer of Providence, R. I. His experience covers over twenty-three years in the field of engineering research in management, and he is the originator of a method for analyzing the job and adopting it to engineering and mechanical application. He was connected for many years with the Sayles Finishing Plants, Inc., as an executive.

* * * * *

As we go to press, word has come of the death of **George B. Wharen,** professor and head of the department of mechanical engineering of the University of North Dakota. Professor Wharen was graduated from Pennsylvania State College, receiving his B.S. in 1910 and his M.E. in 1913. He was then connected with the drafting department of the American Locomotive Co., the motive-power department of the Pennsylvania Railroad Co. and as an instructor in mechanical drawing in Wentworth Institute, Boston.

* * * * *

F. A Ernst is chief of the engineering division of the Fixed Nitrogen Research Laboratory of the U. S. Department of Agriculture. He has been associated continuously with the fixation of atmospheric nitrogen since early in 1916, when he entered the employ of the American Cyanamide Co. During the war he was an officer in the Ordnance Office of the War Department, assigned to the Nitrate Division, which division had the responsibility of constructing and operating Government atmospheric nitrogen fixation and conversion plants. Since 1922 he has been engaged more particularly on the engineering phases of the direct synthetic-ammonia process for fixing nitrogen at the higher pressures. He is a graduate of Lafayette College.

* * * * *

F. C. Reed is a mechanical engineer at the Fixed Nitrogen Research Laboratory of the U. S. Department of Agriculture. He is a graduate of the University of Michigan, class of 1908. He was formerly engineer for the Westinghouse Machine Company, and for 10 years engineer with the Ingersoll-Rand Company. He is the designer of the new line of high-grade centrifugal pumps built by the Cameron Steam Pump Works.

* * * * *

Frank W. Kouwenhoven, at present secretary-treasurer of the A.S.M.E. Baltimore Section and an instructor in mechanical engineering at the Johns Hopkins University, was graduated from the Polytechnic Institute of Brooklyn in 1916. He spent the next two years as a member of the testing departments of various power companies in New York City, and during the war served as a private in the Air Service. Some time after the war he entered the manufacturing engineering department of the Winchester Repeating Arms Company. In the fall of 1920 he joined the mechanical engineering staff of the Johns Hopkins University. He became interested in milk-bottle design in 1923, and since then has worked along this line for both bottle manufacturers and dairy companies.

* * * * *

K. C. Sclater is assistant petroleum engineer with the United States Bureau of Mines located at Ponca City, Okla. He was graduated in 1921 from the University of California with the degree of B.S. and then was connected with the Oak Ridge Oil Co., as production engineer.

* * * * *

The three addresses on Diesel-electric locomotives, extracts of which are published in this issue, were given by **Harte Cooke, N. W. Storer** and **C. H. Stein,** who are respectively chief engineer of the McIntosh-Seymour Corporation, Auburn, N. Y., consulting engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., and general manager of the Central Railroad of New Jersey.

MECHANICAL ENGINEERING

Volume 48 June, 1926 No. 6

Aspects of Steam Power in Relation to a Hydro Supply

By A. H. MARKWART,[1] SAN FRANCISCO, CAL.

Steam power, in a regional power system having a hydro supply as its basis, either because it was started that way or because fuel may for a time have been costly, has greater significance than is generally conceded. Steam power becomes increasingly important as hydro sources become more remote and costly of development; as the annual load factor may tend to lower; as the public may demand higher standards of service; as those manufacturing industries requiring greater continuity of service may grow; as hydro generating and transmission units may increase in capacity; as stream-flow plants without storage regulation become more numerous; and as cyclic changes in water run-off, becoming revealed, may indicate hydro deficiency.

Briefly, steam power is needed

1. *To effect the best system economy*
2. *For stand-by*
3. *For meeting the seasonal hydro deficiency during the short-water period on non-regulating streams*
4. *For meeting the dry-year hydro deficiency.*

The above phases, together with hydro capacity and cost of power, are broadly discussed in what follows.

WHENEVER a system load factor is less than unity and when the capital cost of steam plants at load centers with relatively short transmission is less than that of hydro plants with long transmission, it will be economical to carry a portion of the system peak by steam plants. In general, the cost of energy from steam plants at high load factors exceeds the cost of that from hydro plants because of the fuel charges, whereas the cost of energy from hydro plants at low factors exceeds the cost of that from steam plants on account of the higher fixed charges.

Fig. 2 shows a load curve having an annual load factor of 67 per cent. It is typical of that of the Pacific Gas and Electric Company, which has an annual load factor varying from 60 to 64 per cent. This curve takes the form of twelve daily load curves which are characteristic of the average day of each of the twelve months of the year. It approximately represents the load conditions which have obtained in the past, and its form was determined by averaging the loads of the half-hour periods for the days (including Sunday) of the second week in each month of a selected year. Therefore, in effect, there would be 31 such curves for January; likewise 30 for April. From such a load curve, therefore, may be obtained by an area measurement the kilowatt-hours for an average day for any month, because the area under the monthly curve represents the kilowatt-hours required for the average day of the month in question. By multiplying such kilowatt-hours by the days of the month, the kilowatt-hour demand for the month, and finally for the year, may be obtained.

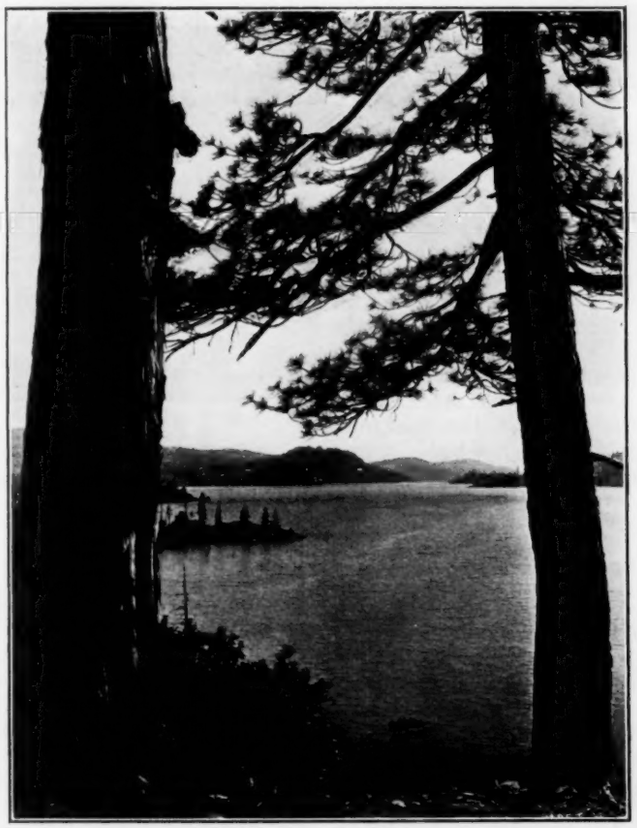

FIG. 1 STRAWBERRY RESERVOIR, PACIFIC GAS AND ELECTRIC COMPANY. A HIGH MOUNTAIN STORAGE RESERVOIR OF 17,900 ACRE-FEET CAPACITY

From this curve were determined the load factor and kilowatt-hours from base and peak for percentages of system peak from 100 per cent to 32.5 per cent. These are shown by Table 1. This curve indicates, for instance, that if 60 per cent of the annual peak from base is carried on hydro plants, 81.8 per cent of the required energy will be supplied on a load factor of 91.7 per cent. If the remaining 40 per cent of the peak is carried on steam plants, what is left, or 18.2 per cent of the required energy, will be supplied at a load factor of 30.6 per cent.

With this information the cost per kilowatt-hour from steam plants and from hydro plants may be obtained under various assumptions of oil, money, operation, maintenance, and depreciation costs, and of capital cost of steam plants and hydro plants including transmission.

Without attempting to develop this, it may be stated that the best theoretical economy in kilowatt-hour cost under present-day conditions with such a load curve is had by carrying approximately 80 per cent of the maximum demand from the base on hydro, and the remaining 20 per cent from the top on steam. But, as a practical matter, steam in excess of this may be carried without material increase in the cost of the mingled kilowatt-hours, as curves which can be prepared will show that there is comparatively little variation in cost over quite a range on either side of the minimum point. Hydro to 75 per cent of the demand, and steam to 25 per cent, may be considered within the range of practical economy. Under this condition the hydro will produce 95.2 per cent of the total annual energy at a load factor of 85.4 per cent, and the steam 4.8 per cent at a load factor of 17.8 per cent.

The foregoing remarks apply exclusively to the idea of economic production of kilowatt-hours, all other considerations being neglected. These statements have as their basis primary hydro

[1] Vice-President in Charge of Engineering, Pacific Gas and Electric Company.

For presentation at the Spring Meeting, San Francisco, Cal., June 28 to July 1, 1926, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

TABLE 1 LOAD FACTORS AND PERCENTAGES OF TOTAL OUTPUT FOR VARIOUS PERCENTAGES OF THE ANNUAL PEAK BOTH FROM BASE AND PEAK[1]

Per cent of annual peak	From base		From peak	
	Load factor	Per cent of kw-hr.	Load factor	Per cent of kw-hr.
100	67.3	100.00	0.0	0.0
95	70.8	99.96	0.3	0.02
90	74.6	99.98	0.8	0.11
85	78.6	99.36	2.9	0.64
80	82.3	97.91	7.0	2.09
75	85.4	95.23	17.8	4.77
70	87.6	91.18	19.8	8.82
65	89.7	86.73	25.5	13.27
60	91.7	81.81	30.6	18.19
55	93.6	76.56	35.0	23.44
50	95.5	70.98	39.0	29.02
45	97.4	65.17	42.6	34.83
40	98.8	58.75	46.2	41.25
35	99.8	51.96	49.7	48.04
32.5	100	47.95	51.7	52.05

[1] Computed for the load curve of Fig. 2, having an annual load factor of 67 per cent.

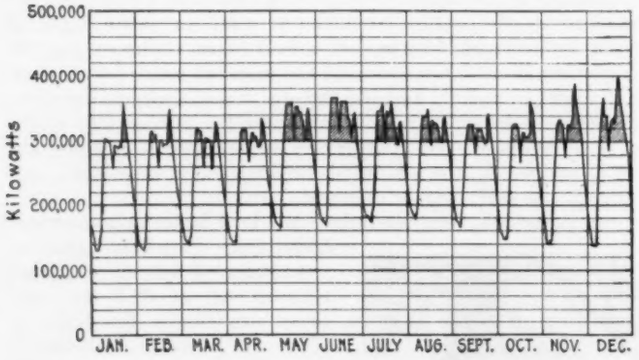

Fig. 2 Typical Daily Load Curve

power, and neglect consideration of years of deficient water supply. They also neglect consideration of the amount of energy which might be generated while running steam plants regularly at reduced loads in order for the steam units to be in that operating condition to render possible such service as stand-by implies.

Were it safe to assume the present-day low fuel prices for an indefinite period, steam power for the base load of a regional supply like that of northern California could compete on very favorable terms with the cost of a combined steam and hydro supply, or a hydro supply. Broadly viewed, however, it would appear to be hazardous to assume such a favorable condition, and unsound from a standpoint of fuel conservation, for obviously it is highly proper in a region where water power is available to use such water power as far as it will go, creating for it as favorable a position as possible by the judicious use of steam power.

Steam Stand-By

Various considerations go to fix the extent of stand-by for a regional hydro power supply. The proper amount of steam capacity to be installed in a regional power system for stand-by purposes should be determined by the amount of preferred service required at metropolitan centers served from such a power system, by the character of the load carried, by the kind of general service which is desired, and by other policy considerations. For a metropolitan load center the maximum amount of stand-by which might be provided would be 100 per cent of the expected metropolitan peak at all times. This would be an exceedingly conservative provision. It is probable that 75 per cent protection would be considered adequate in most instances, for as a rule there is more than one transmission line into such load centers. An installation to furnish this protection would have the capacity to reduce the total peak, permitting hydro to furnish the bulk of the kilowatt-hours on the base at an improved hydro load factor. Experience in northern California shows that a regional system equipped with steam capacity based on 75 per cent of the metropolitan peak will also be a system possessing steam reserve sufficient to supply steam kilowatt-hours on a base load in dry years when the hydro supply is deficient.

Energy production from stand-by plants will vary with the size of the units which are installed or which may be installed from time to time. It will also vary with the hours of operation, or the duration of the hydro system interruption, the amount of stand-by load carried, or the capacity of the hydro or transmission unit which temporarily may be out of service, and the quantity of load that the plant may be required to carry at any instant.

The larger the unit, the greater the number of kilowatt-hours generated, even when standing by to take full or partial loads, as units of 15,000 kva. may be operated to carry a minimum load of 1000 kw., while a 35,000-kva. high-pressure unit probably cannot be operated feasibly with a reduced load of less than, say, 3000 kw.

As a large system may have several steam plants, the kilowatt-hours produced from such stations will vary with the number of stand-by plants and the number of units that may be operating in the several plants.

The experience of the Pacific Gas and Electric Company with four steam plants having a total of twelve units, none larger than 15,000 kva., indicates a kilowatt-hour output of 3 per cent of the total system load as a minimum. This is in addition to that percentage of output which is required to effect the best hydro-steam system efficiency, and does not include the steam generation necessary to make up for interruptions to the hydro service. This latter may be large or small, depending upon the nature and gravity of the failure in the hydro system.

Steam for Short-Water Season

When the hydro supply is put on a suitable load factor by reason of combing off a portion of the peak on steam, the amount of which has been determined by economic study, ideal conditions for the hydro do not even then necessarily exist. Conditions would be ideal if the stream-discharge curve were identically the shape of the hydro-load curve which remains after the steam has supplied its

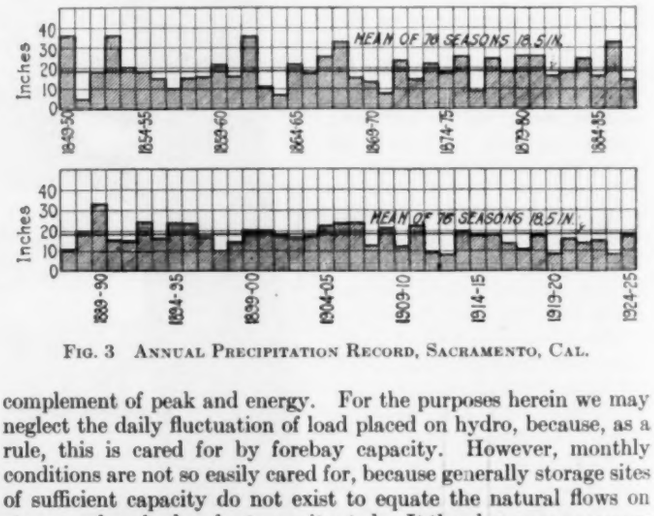

Fig. 3 Annual Precipitation Record, Sacramento, Cal.

complement of peak and energy. For the purposes herein we may neglect the daily fluctuation of load placed on hydro, because, as a rule, this is cared for by forebay capacity. However, monthly conditions are not so easily cared for, because generally storage sites of sufficient capacity do not exist to equate the natural flows on streams where hydro plants are situated. It then becomes necessary during the short-water season, extending from three to six months and depending upon character of watershed and the year, to build up the difference between the actual and the desired monthly hydro block by pulling steam. This does not mean that steam-plant capacity would be provided in addition to that determined by other considerations such as stand-by at load centers or steam capacity to meet years of deficient run-off.

It behooves the power companies to use every effort to effect all possible storage to meet the seasonal short-water condition, because it means a saving of fuel, which is an important matter, particularly in those years when fuel cost is high.

The foregoing statements relating to seasonal stream flow refer largely to primary hydro power which is available the larger portion of the time. It should be noted, however, that under some circumstances it may be economic to make use of additional steam to permit the absorption of secondary power. Under such a plan of using stream flow, steam-plant operation would be required to an even greater extent than would be required with primary hydro power during the short-water season.

Seasonal steam-generated energy will tend to increase because of the desirability, in the public interest, of absorbing by-product

power from storage works erected primarily for irrigation. Since agriculture is fundamental, land for it should be developed to the greatest extent that can be shown economic, proper balance of crop production and demand considered. Such by-product plants must be increased in power capacity to absorb the power of the annual irrigation flow, 60 per cent of which occurs during the three summer months. Power from such plants is largely secondary, as the flow of water is determined wholly on the basis of irrigating the maximum number of acres of land. Under such a condition the seasonal make-up from steam would be greater than that where water is held in such reservoirs to a desired level and discharged at a rate better to answer the power needs rather than the irrigation demand of the maximum number of acres.

DRY-YEAR STEAM

The power companies in California have been operating for about thirty years, and reliable water run-off records for most of the streams are available for about twenty years of this time. It appears that the last eight or nine years, which cover the period of greatest expansion in the industry, have been deficient in precipitation; in fact, a number of these latter years have been abnormally dry.

While the run-off records are not available for a long time, fairly reliable precipitation records are. Fig. 3 is a monthly and annual precipitation record for the city of Sacramento for 76 seasons, commencing with the 1849–50 season and closing with the 1924–25 season. While this chart cannot deal quantitatively with the power problem because it does not indicate run-off, it does give a qualitative picture of the situation and serves to emphasize future low water yields, as the run-off of the streams of the state of California depend exclusively upon precipitation, either in the form of water or snow, except as some of its rivers may be influenced by underground contributions outside of the state, such as is supposed to obtain in the case of the Pit. Even drier years may obtain, because it is believed that a period of at least 100 years is necessary in order to measure the effect of all the cyclic changes which might be expected. At any rate, a study of the chart is of peculiar interest at this time. Briefly, the chart says this: The normal rainfall for the 76 seasons is 18.5 in. During the period named the minimum precipitation was 4.7 in., occurring in the season 1850–51, and the maximum was 36.4 in., occurring in the season 1852–53. There were 46 seasons out of the 76 in which the precipitation was below normal, and 30 in which the precipitation was above normal. Of the 76 seasons there were only 24, or one-third, that were substantially above normal. A further disappointing disclosure is that the normal as now determined from the available record is going down, this being particularly emphasized by reason of the abnormality of precipitation of the eight seasons preceding the 1924–25 season, two of which were less than one-half normal.

It must be inferred, then, that power would have had to be supplied to make up the hydro deficiency during those dry years when the water supply fell substantially below normal, if the capacity of hydroelectric developments is in general based on flows of years of normal run-off, which is likely. It appears that the last eight seasons have been the longest continued dry period in the 75 of record. As a matter of fact, this dry period extends back the last 10 seasons if we neglect the 1915–16 precipitation of 18.3 in. The other dry periods may be noted to be either from two years long to not more than seven years. Of course it is recognized that quantity of precipitation is not the only index as to the water yield of a stream. For instance, the distribution of precipitation in the form of rain and snow in a season having, say, 18 in. might be such as to produce far more beneficial and sustained run-off than would one having 25 in., largely rain, where a bulk of this concentrated in any one month, especially were such precipitation to occur in the early fall before the cold weather comes. Actual run-off, of course, is the real criterion of the power yield of any stream, but, as stated above, the chart does give a picture which will suggest a deficiency of hydro energy during the years of deficient precipitation.

Roughly, a system like the Pacific Gas and Electric Company's is deficient one-third in energy output on the basis of dry years of severity that have thus far obtained. Actually, the annual run-off of streams in the northern part of the state was deficient a greater amount than this, probably from 40 to 60 per cent taking 1923–24 as the criterion. The difference in the deficiencies comes about because of the extent to which the streams have been developed. In other words, they have not been developed for the high flow which is available for but few months of the year, but rather for the flow that is reasonably sustained throughout the greater part of the year as this was known from records available up to the several times of their development.

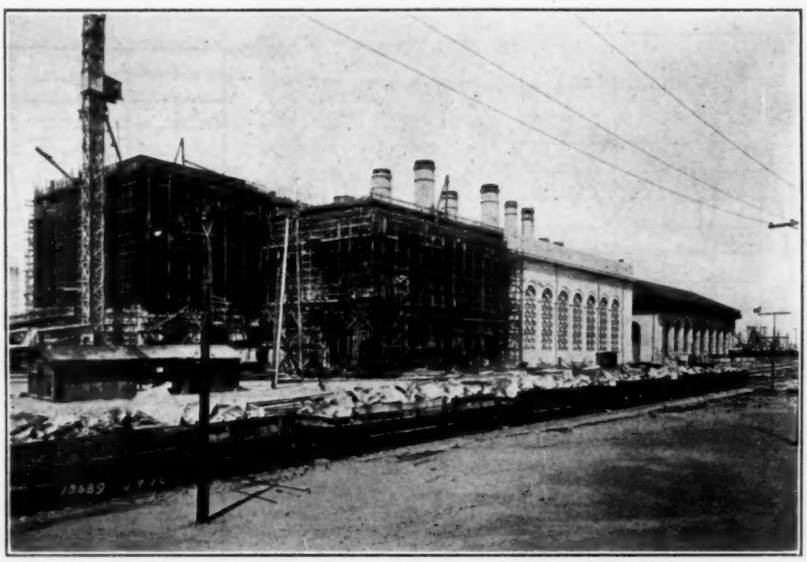

FIG. 4 LONG BEACH PLANTS NOS. 1 AND 2, SOUTHERN CALIFORNIA EDISON COMPANY, SHOWING A 50,000-KVA. ADDITION IN PROGRESS OF CONSTRUCTION; TOTAL CAPACITY, 205,000 KVA. A LARGE STEAM PLANT AT AN IMPORTANT METROPOLITAN LOAD CENTER IN A REGIONAL HYDROELECTRIC SYSTEM

What actually takes place in dry years, as contrasted with normal years, is that the steam power takes its position on the base of the load immediately above the load that can be carried by stream-flow plants which are not subject to daily regulation. The portion of the load lying above the steam will be carried on those hydro plants which have forebay regulation, as far as they can, and the final balance by the steam plants, if the steam plants are not already carrying their capacity on the bottom. This normal- and dry-year contrast is shown by actual daily load curves of the Pacific Gas and Electric Company in Figs. 5 and 6, the former being for August, 1924, under conditions of drought, and the latter being for May, 1925, when water conditions were fairly normal. In both cases, however, the peak pulled was about the same.

Thus, if power consumption is not to be curtailed, power companies must provide the steam-plant capacity required in the dry years, because this is a condition—not a theory. In other words, were it assumed for one reason or another that steam stand-by protection at load centers was superfluous, or combing off the peak because of good economic showing on the hydro was unnecessary, steam would in any event be required to that extent necessary to meet hydro deficiency in these extremely dry years. This steam-plant capacity, as determined by experience, should be in this region of the order of 40 per cent of the anticipated system peak, and it may even be greater than this in other portions of the state.

As a coincidence resulting from the relation which exists between the metropolitan and system peaks on the system of the Pacific Gas and Electric Company, a steam-plant capacity of 40 per cent of the system peak also will approximate 75 per cent of the metropolitan peak. This will of course change as the relation changes, and as more hydro plants are built on streams of sustained flow like the Pit River or on streams which may be regulated by storage works. As has been stated, the kilowatt-hour production of the hydro sys-

tem as now developed in northern California is deficient during dry year to the order of one-third. This deficiency may be made up readily from steam-generating stations having a capacity of 40 per cent of the system peak or 75 per cent of the metropolitan peak. For example, with a system peak of, say, 400,000 kw., of which 213,000 kw. is the load of metropolitan centers, steam capacity of 160,000 kw. at load centers would be sufficiently great to furnish the deficient hydro kilowatt-hours to the general system in dry years when employed on the base, and normally furnish suitable protective capacity at metropolitan centers. Likewise, this steam capacity would permit combing off the peak under normal operation to any amount that was desired to improve the hydro load factor to bring the best system economy.

As an operating problem in dry years, if during the precipitation period it appears that the stream yield for the coming run-off season is likely to be deficient, it becomes necessary to use good judgment in the holding of stored waters and the burning of oil during the spring months so that, in the late summer, the power available from steam plants and used on the base, together with that available from re-

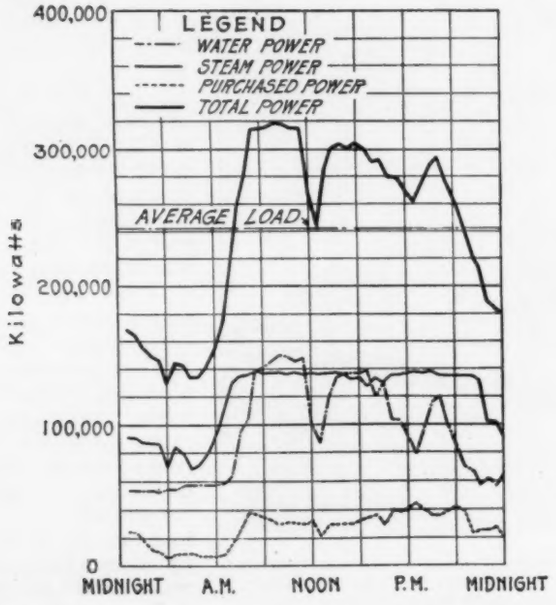

Fig. 5 Daily Load Curve, Pacific Gas and Electric Co., Aug. 21, 1924

served waters when used on the top, will be sufficient to meet the anticipated load.

Under such conditions the steam plants, up to their capacity, must take of the total load a block of a size as determined by the amount that the hydro of waters held in storage will meet. Thus during a dry year the variations in loads are taken up by stored-water plants, whereas in normal years variations are taken by steam plants and stored water, except as daily variations are concerned, serving together with the stream flow to meet base-load requirements.

While the maximum overall economy of a regional system in normal-water years is had at present by generating the maximum of hydro energy at a high load factor and the minimum of steam energy at low load factor, it is desirable in the interests of economy to use stored water through hydro plants in a manner which will permit the highest possible daily load factor on steam for the obvious reason that the kilowatt-hours from a unit of fuel increase as the load factor improves. In modern steam-turbine plants, with boilers of 400 lb. pressure, it is possible to produce 400 kw-hr. per barrel of oil at load factors of 70 per cent and above, with less as the load factor lowers, down to perhaps 250 kw-hr. per barrel with a load factor as low as 10 per cent. While in normal years it may not be possible to operate for ideal fuel consumption, it is quite possible to do so in dry years. In such years, when annual costs become an important consideration, the load factor on steam will be high, with corresponding steam-plant efficiency.

Normally, steam plants must be used to supply kilowatts of peak, if this function can be imagined, instead of kilowatt-hours of energy, leaving the hydro to supply the bulk of the energy requirements. Under such condition there will be but a minimum of oil consumed, as the amount of energy required from steam when supplying the selected portion of the peak is relatively small.

In dry years, however, steam plants must be used to supply the kilowatt-hours of energy of the base load. At this time operating costs become a very important consideration because of the unproductive investment in hydro plants. Therefore, to improve the economic situation the hydro plants must be operated in a manner that will produce the highest possible load factor on the steam plants with corresponding steam-plant efficiency.

Hydro Capacity

The desired steam-plant capacity in a combined system will be determined by the various considerations elsewhere mentioned. Hydro capacity, on the other hand, is involved solely with the question of economy in kilowatt-hour production. With the increase in distance of transmission, larger capacities of generating and

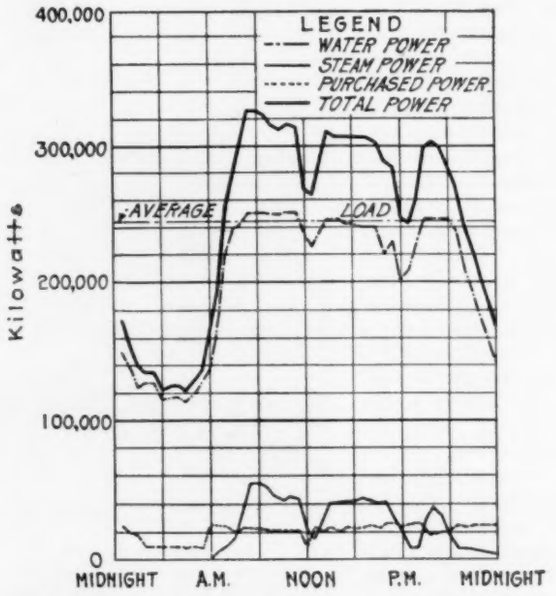

Fig. 6 Daily Load Curve, Pacific Gas and Electric Co., May 5, 1925

transmission units, and higher capital costs of such over steam plants, it becomes necessary to install hydro plants to operate on the highest possible load factor. This is accomplished by combing a proper amount off the peak with steam plants, leaving the base load, containing by far the greater number of kilowatt-hours, for hydro. The hydro-plant capacity must then be that which is necessary to meet the remaining and larger proportion of the load. And streams should be developed for the flow, regulated or unregulated as may be possible, in normal years, with steam to make up the hydro deficiency in subnormal years.

To illustrate again with the example of peak load of 400,000 kw., neglecting the question of spare capacity—which becomes a matter of judgment—a system with an annual load factor of around 60 to 65 per cent would have a hydro capacity of 75 per cent of the peak from the base, or about 300,000 kw. This, together with the steam-plant capacity of 160,000 kw., brings the system capacity to 460,000 kw., with kilovolt-amperes higher, as may be required by power-factor conditions.

Cost of Power

The cost of power from such a regional system naturally will vary from year to year. The total of fixed and other annual charges on hydro and steam-plant capacity will remain substantially the same irrespective of the output, whereas the fuel charge will vary depending upon the hydro deficiency. In dry years a portion of the hydro-plant capacity will be non-productive, and in wet years this condition will obtain with respect to steam-plant capacity. Because

of this the cost of power is therefore not constant, even though unit fuel cost and fixed charges be stationary over a long period of time. However, the average cost of energy may be ascertained with reasonable accuracy, but only if a period of years which contain a dry cycle is considered. It is possible to make a summation of annual costs for such a period and apply these to the total of kilowatt-hours expected from hydro and steam plants for the period, thus obtaining a period average unit cost of energy. The total cost will be made up of the fixed charges on the capital invested in hydro including transmission, and in steam plants, plus operation, maintenance, depreciation, and similar costs on both, plus the fuel costs over the period considered.

FIG. 8 DRUM PLANT, PACIFIC GAS AND ELECTRIC COMPANY. A 37,500-KVA HIGH-HEAD IMPULSE-WHEEL INSTALLATION ON A STREAM. REGULATED BY STORAGE

CONCLUSION

In the final analysis the relative development by a utility of hydro and steam-generating capacity is a problem of economy; and the natural resources which are available, the character of the load to be carried, the rate at which energy must be supplied or the load factor, the extent to which other utilities may depend upon it for stand-by, and other related elements furnish the criteria for its solution. This can be illustrated by reference to the measure of steam capacity prevalent with several of the utilities of this region. The steam-plant capacity of the California-Oregon Power Company, a utility with a small load, is nil, as it serves a sparsely settled territory and its hydro plants enjoy a fairly dependable water supply. The Great Western Power Company has a steam-plant capacity of approximately 20 per cent of its system peak, relatively small but doubtless justified because of its interconnections and the extensive storage capacity which is provided for regulating the stream on which its hydro plants are situated. The Pacific Gas and Electric Company and the Southern California Edison Company, which jointly furnish about 70 per cent of the energy for the state, each have a ratio of steam to hydro capacity which corresponds fairly closely with that outlined in the foregoing. The Los Angeles Gas and Electric Company operates steam plants exclusively, as it serves a city with a high load density, and cheap fuel in the form of natural gas and oil is readily available.

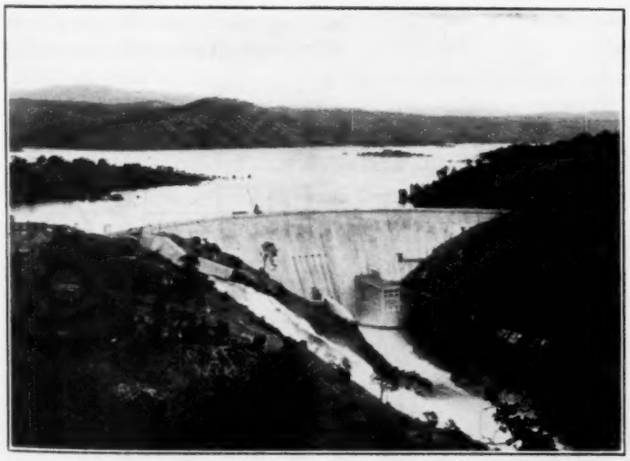

FIG. 7 DON PEDRO DAM AND POWER HOUSE, TURLOCK IRRIGATION DISTRICT, CALIFORNIA; 289,000 ACRE-FEET IN STORAGE, 15,000 KVA. IN POWER. PROVIDES STORAGE FOR IRRIGATION AND ITS BY-PRODUCT, SEASONAL POWER

The general tendency seems to be for the steam-plant ratio to increase slightly. The central-station construction program for eleven western states for the three-year period 1924 to 1926, inclusive, is as follows:[1]

	Hydro kva.	Steam kva.
1924	243,223	139,500
1925	314,625	87,500
1926 (projected)	194,550	145,000
Total	752,398	372,000

For these three years the ratio of steam-plant construction to the total is 33 per cent. The installed generator capacity on Jan. 1, 1925, for eleven western states is given as 3,084,974 kw., of which 30 per cent or 935,783 kw. was steam.

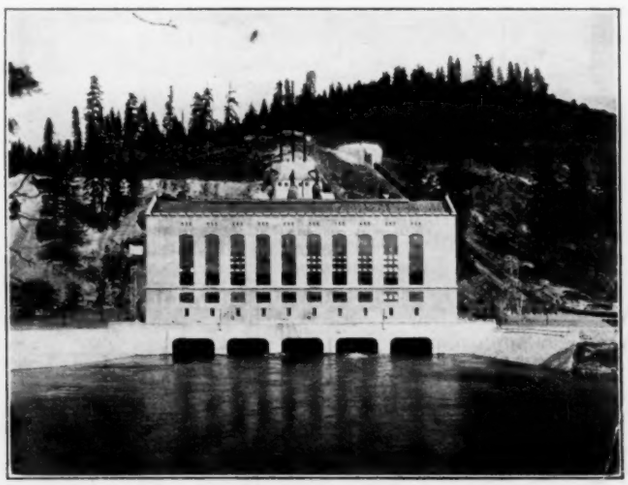

FIG. 9 PIT RIVER NO. 3 PLANT, PACIFIC GAS AND ELECTRIC COMPANY. AN 81,000-KVA. MODERATE-HEAD, REACTION-WHEEL PLANT ON AN UNREGULATED, SUSTAINED-FLOW STREAM, SUPPLYING BLOCK LOAD

The steam ratio will probably remain fairly constant, but with a slightly increasing tendency until the majority of the more favorably situated hydro projects are developed. To predict further into the future is impossible on account of the uncertainty of the cost of fuel. At the present rate of growth the hydro resources will not approach complete development for another generation. The cost of fuel oil may, and probably will, increase, but the supply of low-grade coal which can be substituted will keep the cost of steam within reason, thus permitting fuel to continue to be a factor in the economic development of the remaining hydro resources.

[1] From *Journal of Electricity*, Feb. 1, 1926.

Comparative Performance of Air Preheaters

By NEVIN E. FUNK,[1] PHILADELPHIA, PA.

This paper gives the results of tests on a number of boiler units equipped with air preheaters and one unit using unheated air. All of the boilers are of approximately the same size, are of the same type, and have furnaces and stoker equipments which are similar. Some are equipped with economizers. Different types of air preheaters are used and the areas of the heaters are not the same. The curves which are presented show the comparative performances of the units, the relation between coal fed and flue-gas temperature, the relations between gas-temperature drop and air-temperature rise and percentage of rating, and the relation between the percentage of combustible in the ash and the coal fed.

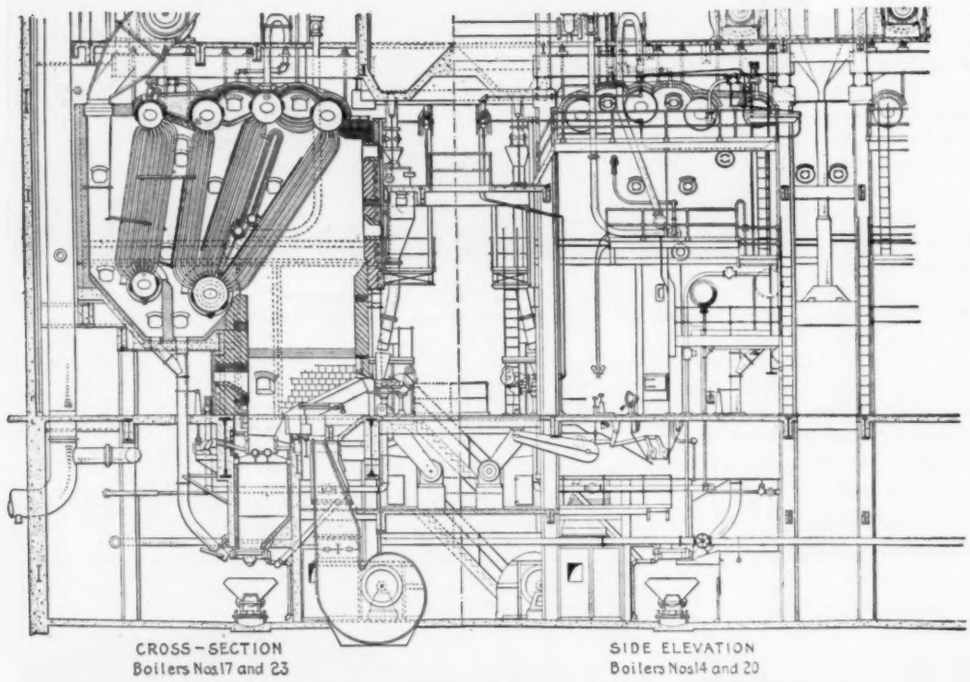

FIG. 1 CROSS-SECTION OF UNIT NO. 23 AT THE DELAWARE STATION

THIS paper presents comparative data on different types of air preheaters used with boilers equipped with economizers and with boilers not equipped with economizers. The boilers in every case are of approximately the same design. It is hoped that the facts presented will be of value to engineers in the design of future stations. However, there is no intention of drawing any specific conclusions from the data presented in view of the danger arising from the general application of conclusions which apply only to a given set of conditions. The data will therefore be presented in comparative form and the conclusions as to the application of the different equipment to designs varying from those herein described will be left to the judgment of each engineer in solving his own individual problem.

DESCRIPTION OF UNITS

The similarity of construction of the boiler units will be noticed in Figs. 1, 2, 3, and 4 which illustrate the complete design of the furnaces, boilers, economizers, and air preheaters in their various relations.

Fig. 1 is a cross-section of boiler unit No. 23 at the Delaware station. On the right-hand side of Fig. 2 is a cross-section of boiler unit No. 5 at the Chester station. In the rear of the economizers is a plate air preheater designed by The Philadelphia Electric Company and developed by Connery Company, Inc. On the left-hand side of Fig. 2 is an elevation of boiler unit No. 6 at the Chester station. The air preheater is a B. & W. plate heater. Boiler unit No. 3 at the Chester station has exactly the same boiler, superheater, and economizer heating surface as Nos. 5 and 6, but the air preheater is of the tubular type of B. & W. design and contains 22,072 sq. ft. of heating surface. On the right-hand side of Fig. 3 is an elevation of boiler unit No. 7 at the Chester station. In this case there is no economizer, the exit gases from the boiler passing directly into two Ljungström air preheaters in parallel. The left-hand side of Fig. 3 shows a cross-section of boiler unit No. 8 at the Chester station which is identical with No. 7 except that the heat in the waste gases is reclaimed by a B. & W. tubular air preheater.

Fig. 4 is a cross-section of boiler

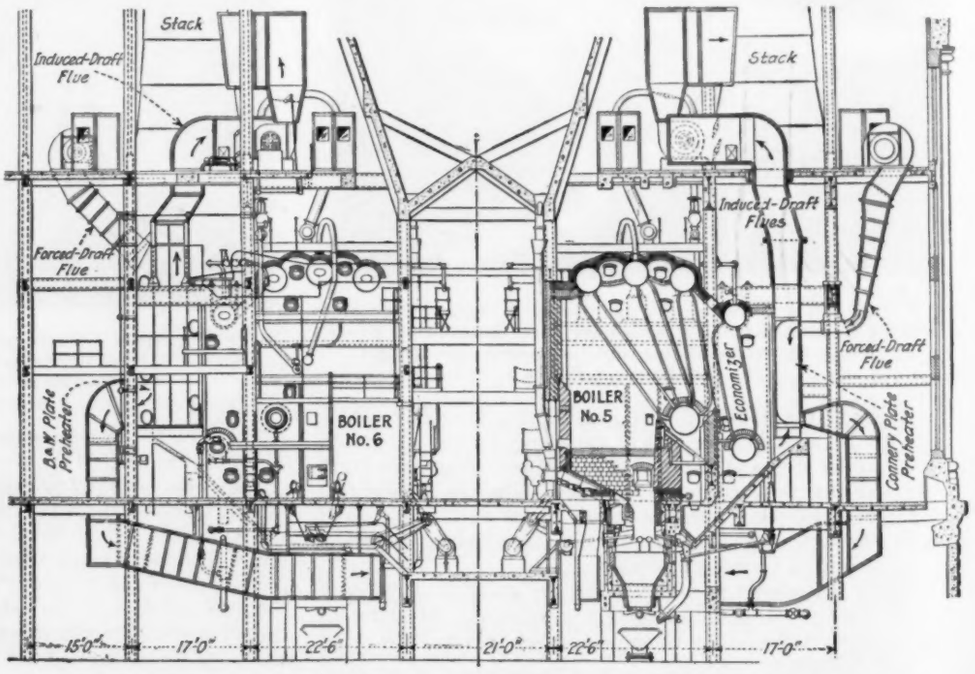

FIG. 2 CROSS-SECTION OF UNIT NO. 5 ON RIGHT, ELEVATION OF UNIT NO. 6 ON LEFT, AT THE CHESTER STATION

[1] Operating Engineer, Philadelphia Electric Company. Mem. A.S.M.E.

Contributed by the Power Division and presented at the Providence, R. I., Meeting, May 3 to 6, 1926, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

unit No. 59 at the Richmond station. The general arrangement of this boiler is the same as that of No. 3 at the Chester station. The air preheater is of the tubular type. The greatest deviation in the design of the furnace of this boiler from those of the Chester boilers is in the use of Bailey water-cooled bridge and side walls. In these, water from the lower drum of the boiler passes through the rear bent-tube connection down the circulating tubes to the bottom header of the water-cooled bridgewall. The top and bottom headers of the water-cooled bridgewall are connected by the tubes supporting the blocks which directly face the furnace and by circulating tubes back of this front row of tubes. This allows a direct circulation between the top and bottom headers of the bridgewall. The top header is connected on the outside of the boiler to the top front water drum as is indicated by the heavy black line on the right-hand side of Fig. 4.

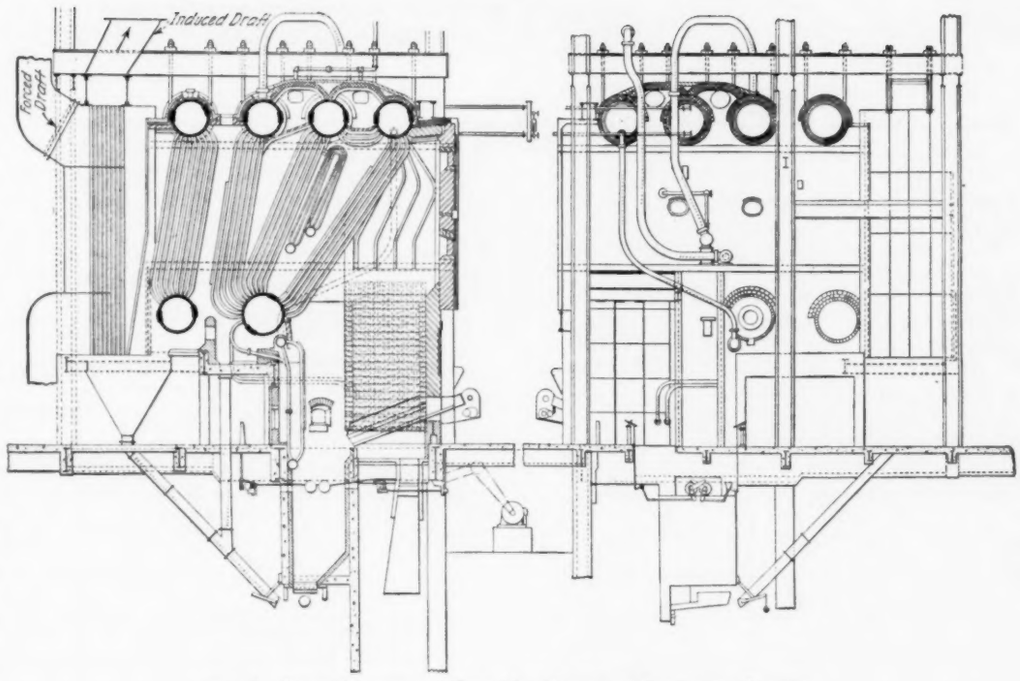

FIG. 4 CROSS-SECTION OF UNIT NO. 59 AT THE RICHMOND STATION

Water also passes from the bottom drum of the boiler through bent tubes outside of the boiler housing and progresses toward the front of the boiler to the bottom header of the Bailey side walls. These tubes are shown in heavy lines at the bottom of the right-hand side of Fig. 4. From this bottom header the water rises through the tubes, to which the blocks are attached, to the top header and thence through four bent tubes inside of the furnace to holes in the bottom of the top front drum, from which the usual tubes passing between the top and bottom drums have been omitted.

COMPARISON OF EQUIPMENT

Table 1 has been compiled to permit of a rapid comparison of the characteristics of the heating surface of the boiler units. Attention is called to the fact that all the Chester boilers and superheaters, as well as the Delaware boiler and superheater, have exactly the same amount of surface area. All the Chester boilers with economizers have the same amount of economizer-surface area while the Delaware boiler has a somewhat larger economizer-surface area. The small air preheaters at Chester have approximately the same amount of area of heating surface while the two large preheaters vary considerably in area, due to the wide variation in the types of these preheaters.

The Richmond boilers, superheaters, and economizers are somewhat larger than the other units but the ratios of their superheater and economizer heating-surface areas are about the same. The preheater heating-surface area of the Richmond boiler is the same as that of the tubular preheaters at Chester but since the boiler is larger the ratio of preheater heating-surface area to boiler heating-surface area is somewhat smaller. In addition, the Richmond boiler has 595 sq. ft. of water-cooled furnace walls, which is equivalent to 3.79 per cent of the boiler heating-surface area.

Table 2 shows the similarity of the stoker and furnace characteristics of the boiler settings.

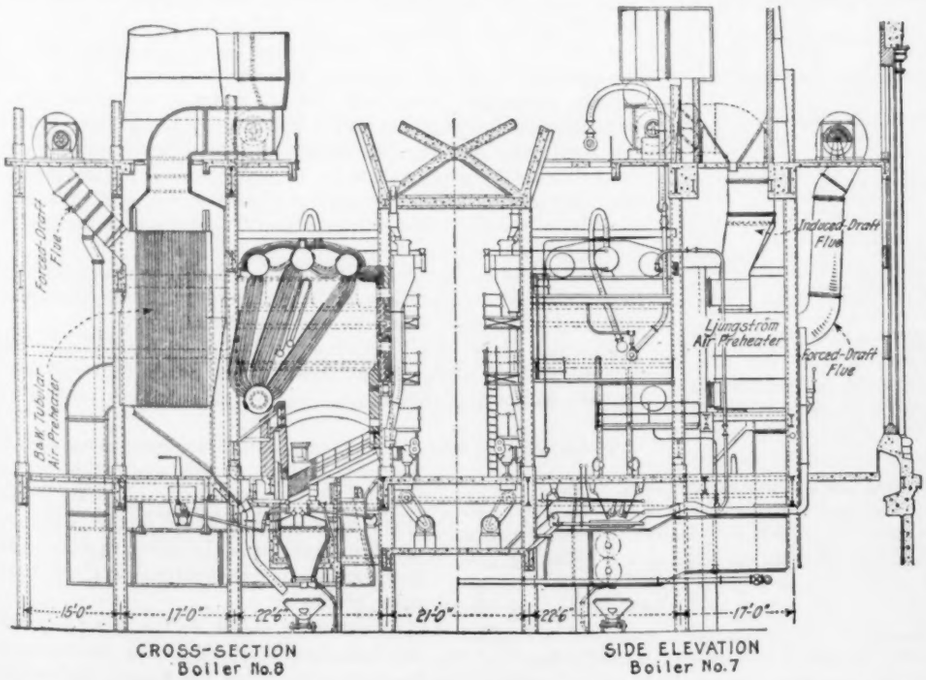

FIG. 3 ELEVATION OF UNIT NO. 7 ON THE RIGHT, CROSS-SECTION ON UNIT NO. 8 ON THE LEFT, AT THE CHESTER STATION

AIR PREHEATERS COMPARED

In Table 3 are given the physical characteristics of all the preheaters with the exception of the Ljungström, which cannot be compared with the others on the same basis. In comparing the characteristics of these preheaters with each other and with a boiler without any preheater, the boiler numbers have been placed on all the curves to indicate to what units they particularly apply. To review the physical characteristics of the units compared, the following tabulation gives the economizer and air-preheater equipment of all of the boilers:

Boiler No.	EQUIPMENT
3	Economizer and small tubular air preheater
5	Economizer and small plate preheater, Connery type

TABLE 1 BOILER-INSTALLATION CHARACTERISTICS

(B. & W. Stirling Boilers, 55 tubes wide)

Station	Boiler No.	Date installed	Heating Surface: Boiler	Superheater	Economizer	Preheater	Water wall	Economizer feed temp., deg. fahr.	Approximate Final Steam Condition: Lb. per sq. in. gage	Total temp., deg. fahr.
Chester	3	10/31/24	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	5,250 sq. ft. 36.95%	22,072 sq. ft. T 154.8%	.....	172	257	652
	5	2/14/25	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	5,250 sq. ft. 36.95%	20,719 sq. ft. P 145.7%	.....	172	257	652
	6	12/6/24	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	5,250 sq. ft. 36.95%	22,500 sq. ft. P 158.2%	.....	172	257	652
	7	2/5/25	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	.....	64,960 sq. ft. L 457.0%	.....	172	257	652
	8	6/1/25	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	.....	50,276 sq. ft. T 353.5%	.....	172	257	652
Delaware	23	7/5/24	14,217 sq. ft. 100%	2,582 sq. ft. 18.15%	6,853 sq. ft. 48.2%	.....	.....	167	257	633
Richmond	59	10/8/25	15,692 sq. ft. 100%	2,822 sq. ft. 17.9%	7,515 sq. ft. 47.85%	22,072 sq. ft T 140.7%	595 sq. ft. 3.79%	235	410	658

T = Tubular air heater L = Ljungström heater P = Plate-type heater

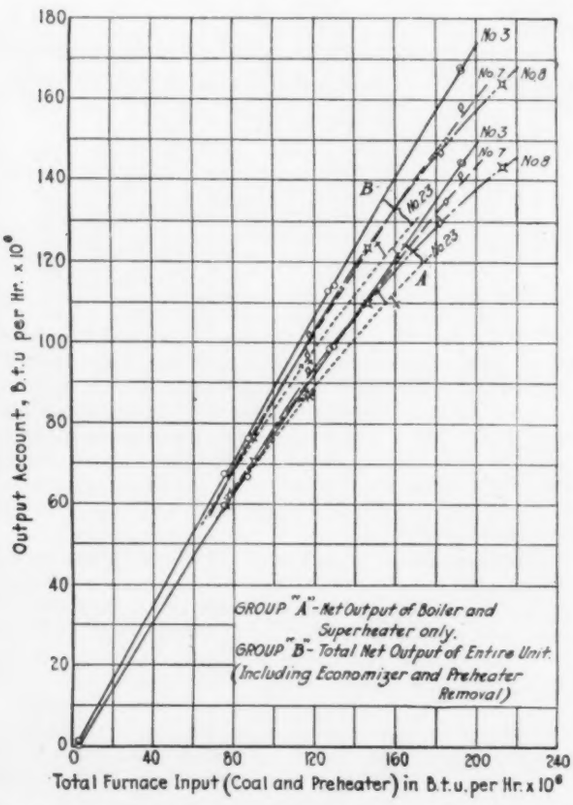

FIG. 5 RELATION OF TOTAL HEAT OUTPUT TO TOTAL HEAT INPUT

TABLE 2 STOKER CHARACTERISTICS

(American Engineering Co., Taylor, Type H.C.7)

Station	Unit No.	Grate surface, sq. ft.	Number of rams	Number of tuyeres	Furnace: Volume above ashpit, cu. ft.	Furnace: Height of mud drum from floor, ft.	Ashpit at heel of fire: Width, ft.	Ashpit at heel of fire: Depth, ft.
Chester	3	310	15	21	6650	11	3.8	5.3
	5	310	15	21	6650	11	3.8	5.3
	6	310	15	21	6650	11	3.8	5.3
	7	310	15	21	6650	11	3.8	5.3
	8	310	15	21	6650	11	3.8	5.3
Delaware	23	310	15	22	7200	13	3.8	4.0
Richmond	59	360	15	25	7780	13	3.8	5.3

TABLE 3 PREHEATER CHARACTERISTICS

Boiler No	3	5	6	7	8	59
Heating surface, sq. ft	22,072	20,719	22,500	64,960	50,276	22,072
Type	Tubular, B. & W.	Plate, Connery & Co.	Plate, B. & W.	Rotary Ljungström	Tubular, B. & W.	Tubular, B. & W.
Rows of tubes	15	...	...	...	41	15
Tubes per row	90	...	...	...	75	90
Tube diameter—or thickness of gas passage, in	2½	⅝ (gas)	1¼	...	2½	2½
Metal thickness	12 B.w.g.	1/16 in.	16 B.w.g.	...	12 B.w.g.	12 B.w.g.
Length of tube, ft	25	...	...	...	25	25
Overall duct height, ft	...	15	24	...	...	...
Overall duct width	...	3 ft. 2 in.	...	...	...	...
Number of gas ducts	...	252	...	...	...	...

Boiler No.	EQUIPMENT
6	Economizer and small plate preheater, B. &. W. type
7	Ljungström air preheater only
8	Large tubular preheater only
23	Economizer only
59	Economizer, small tubular air preheater and water wall.

COMPARISON OF PERFORMANCES

The performances of boiler and economizer units equipped with air preheaters cannot be considered on the basis of the heat in the fuel introduced into the furnace alone, but must be compared on the basis of total heat injected into the furnace. This includes the heat in the fuel and the heat in the air above atmospheric temperature.

In Fig. 5 are two families of curves. Group A indicates the output of the boiler and superheater alone. Group B indicates the output of the entire unit including economizer and preheater. It is to be noted that the performance of the boiler alone without preheated air is poorer than that of any of the boilers using preheated air, and that except at fairly high ratings there is little difference in the performances of those using preheated air at low and those using preheated air at high temperatures. With the increase in rating, however, the boiler supplied with preheated air at low temperature maintains a much higher output ratio than do the two supplied with preheated air at higher temperature.

Personally, the author has no doubt about the accuracy of tests of units 7 and 8 in so far as their relation to the test of unit No. 3 is concerned, but he is inclined to believe that, although these were the actual performances obtained from the boilers, they are not indicative of what may be expected with highly preheated air. His belief is based on two outstanding conditions which prevent the attainment of high efficiency with these units. First, at high ratings, the furnace refractories will not stand up under the higher preheated-air temperatures and it is necessary therefore to reduce the percentage of CO_2 somewhat to preserve the furnace walls. Second, with the greater quantity of heat liberated in the furnace, the boiler alone apparently does not absorb as much and the temperature of the exit gases rises rapidly. This puts an extra burden on the air preheaters.

The first condition can be met by water-cooled furnace construction. The second condition can be corrected by the installation of increased boiler surface or a change in boiler baffling.

This year boiler No. 7 will have a Bailey wall installed in the furnace, and the author firmly believes that future tests will show that the efficiency of this unit can be favorably compared with that of No. 3.

The B group of curves merely substantiate the conclusions drawn for the A group. It will be noted, however, that the curves for units 7 and 8 are much closer together than those of the A group, which indicates that the tubular preheater is performing somewhat better than the Ljungström preheater.

Attention is called to the fact that unit No. 3 is showing a still better performance than either No. 7 or No. 8 since the deviation of the curves for these units and that for

unit No. 3 is greater in the B group than in the A group. This, however, is due largely to the fact that the economizer is reducing the flue-gas temperatures so that the air temperatures do not rise as rapidly as they do in Nos. 7 and 8.

Fig. 6 shows the efficiencies of the units at different rates of fuel consumption. These are overall efficiencies of boiler, superheater, economizer, and air preheater. There are some very distinct differences in the shapes of these efficiency curves. Unit No. 23, which has no preheater, shows a distinctly rapid drop in efficiency with increase in rating. Unit No. 3, which is practically the same as No. 23, except that an air preheater has been supplied, shows an unusually flat efficiency curve.

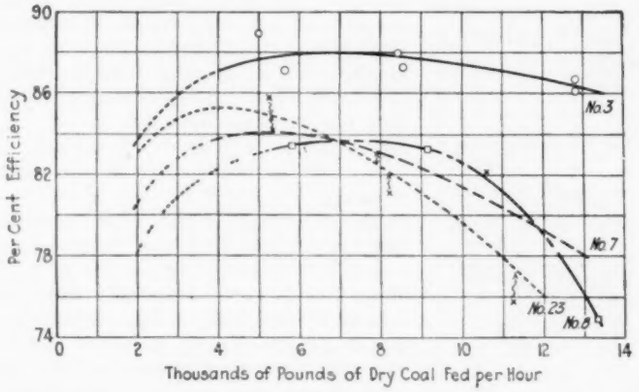

FIG. 6 RELATION OF BOILER EFFICIENCY TO RATE OF FUEL FEED

$$\text{Per cent efficiency} = \frac{\text{Net heat in steam}}{\text{Total heat in coal fired}} \times 100$$

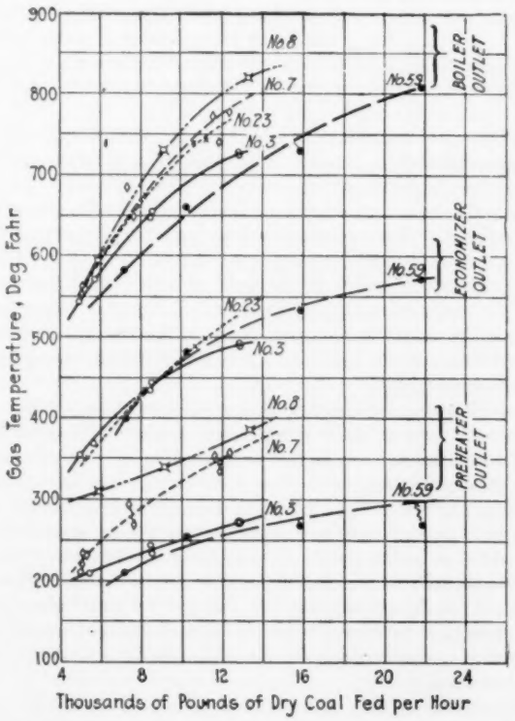

FIG. 7 RELATION OF GAS TEMPERATURES TO RATE OF FUEL FEED

The efficiencies of units 7 and 8, which have the large air preheaters, are distinctly lower than the efficiency of No. 3, although they are somewhat flatter than and at heavy loads higher than No. 23. Unit No. 8 shows a very rapid dropping off in efficiency, not due to the characteristics of highly preheated air, but to the fact that the boiler furnace is not properly designed to care for the high temperatures. The rapid downward bend in the efficiency curve of unit No. 8 is accompanied with severe burning of the extension grates of the stoker. This is apparently caused by the reflected heat from the bridgewall, and if the performance of a stoker with a similar ash-discharge end can be used for comparison, the installation of a water-cooled wall at this point would raise by 3 or 4 per cent the lower end of the curve for unit No. 8.

COMPARISON OF FLUE-GAS TEMPERATURES

In Fig. 7, comparative data are given on the boiler, economizer, and preheater-outlet gas temperatures. Attention is called to the fact that both units 7 and 8 with the highly preheated air have higher outlet temperatures than unit 23 with cold air. Unit No. 3, however, with a preheated-air temperature of 300 deg. fahr., has an outlet gas temperature considerably lower than that of unit No. 23, and unit No. 59 with the Bailey walls has a lower temperature than any of the others. The economizer-outlet temperatures are approximately the same for all units having economizers, that of unit No. 3 being somewhat lower than that of No. 59. The increased temperature of economizer-outlet gas in unit No. 59 is primarily due to the fact that the feedwater temperature is 63 deg. fahr. higher than that of unit No. 3.

The air preheaters on Nos. 3 and 59 are identical, and the exit gases from these two preheaters are at practically the same temperature. The air preheaters on Nos. 7 and 8, however, have considerably higher exit-gas temperatures, due apparently to the higher exit temperatures of gas from the boilers. This condition is more clearly shown in Fig. 8, in which the temperature drop in the flue gas and the temperature rise in the air supplied to the stoker have been plotted against percentage of boiler rating.

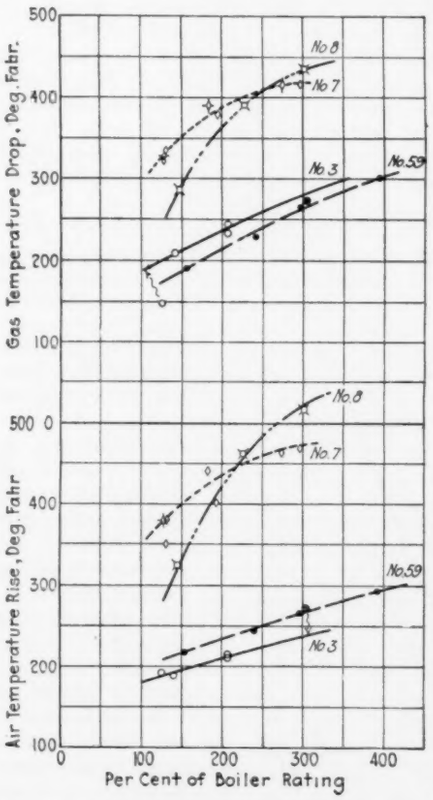

FIG. 8 TEMPERATURE CHANGES THROUGH AIR PREHEATER. RELATION OF GAS-TEMPERATURE DROP AND AIR-TEMPERATURE RISE TO BOILER RATING

RATE OF HEAT TRANSFER

It is interesting to note the rate of heat transfer through air preheaters of different types. The curves of Fig. 9 have been plotted to show the relation between the temperature drop of the gas and the temperature rise of the air. The temperature increment for the preheaters of units 7 and 8 is greater than that for units 3 and 59. Apparently this is caused by the rapid increase of the temperature of the outlet gases in these two boilers. This throws more work on the air preheaters, increases the average temperature through the air preheater, and permits of a high rate of heat transfer.

When new, the performances of the plate-type air preheaters are quite equal to those of the tubular air preheaters. It is, however, much more difficult to keep the plate-type air preheaters clean. For this reason comparisons of these different-type air preheaters should be made after they have been in service for some time. With the desire to get accurate comparisons of the yearly performance that could be expected from the plate and the tubular preheaters, units Nos. 3, 5, and 6 were allowed to run under the same load conditions for about nine months before the data included in Fig. 10 were obtained. It will be noted that there is a considerably less rise in the temperature of the preheated air in the two plate heaters than in the tubular heater. Likewise the temperature drop in the gases is less in the plate heaters than in the tubular heaters.

EFFECT OF AIR TEMPERATURE ON COMBUSTIBLE IN ASH

The figures of relative temperatures for units Nos. 3, 5, and 6 are given with the understanding that they are not to be compared with data from twenty-four-hour tests of clean boiler units, but are of relative value for boiler units under the usual operating conditions. They were taken from the charts of recording meters, and, while an attempt was made to operate the boilers close to the average rating as plotted, there was some variation above and below this rating due to the fluctuations in station loading, and this, of course, has some effect on the performance of the thermometers. Figures substantiating the values given can be taken directly from the charts on these various boilers and always show a lower temperature of preheated-air for the plate heaters than for the small tubular heaters.

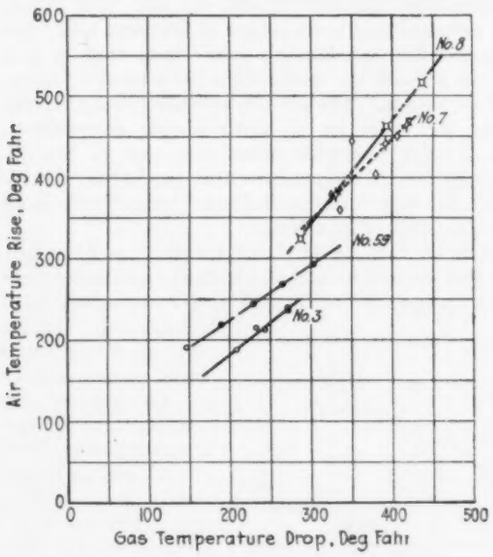

FIG. 9 RATIO OF GAS-TEMPERATURE RISE TO AIR-TEMPERATURE DROP IN AIR PREHEATERS

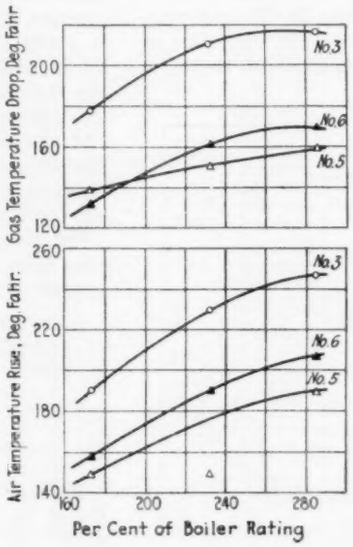

FIG. 10 COMPARISON OF TEMPERATURES FOR PLATE AND TUBULAR HEATERS OF EQUIVALENT HEATING SURFACE

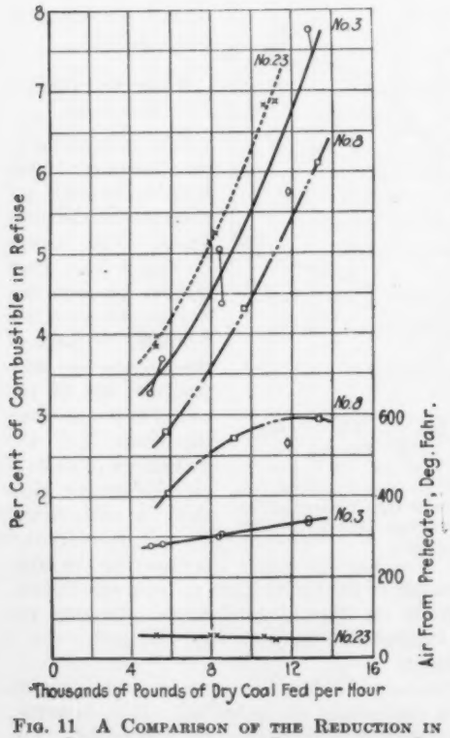

FIG. 11 A COMPARISON OF THE REDUCTION IN THE COMBUSTIBLE IN THE REFUSE WITH INCREASE IN PREHEATED-AIR TEMPERATURE

Some figures have been given in the past showing the reduction in the amount of combustible in the ash with the use of preheated air, and for this reason the author feels that the data given in Fig. 11, which show a variation in the percentage of combustible in the refuse with variation in rating and with various temperatures of preheated air, will be of considerable interest because they not only bear out data heretofore presented but also show a very definite change with the change in temperature of preheated air.

In Fig. 11 have been plotted the change in temperature of preheated air with the rate of coal feed, and the change of the percentage of combustible in the refuse with the rate of coal feed. The air temperature for Unit No. 23 is that of the boiler room, and the fact that it has decreased slightly with the increased rating merely shows that the room temperature has varied, since this air temperature has no relation to the boiler rating. It will be noted that the curve of combustible in the refuse for unit No. 23 is the highest of all. The temperature of preheated air of unit No. 3 varies from slightly below 300 deg. fahr. to about 350 deg. fahr. and the combustible in the refuse for varying ratings of this unit is less by about $\frac{1}{2}$ per cent than the combustible in the refuse of unit No. 23. It must be noted at this time, however, that the ashpit of unit No. 3 is somewhat deeper than that of No. 23 and this in itself may be responsible to some extent for the reduction in the refuse. The air temperature for unit No. 8 varies from 400 to 600 deg. fahr., and it is extremely interesting to note that the combustible in the refuse from unit No. 8 is the lowest of all; that is, the boiler with the highest preheated-air temperature has the lowest percentage of refuse in the ash. The ashpits of units Nos. 8 and 3 are practically identical. The small diamond on Fig. 11 is a spot test for boiler No. 7, and it is worthy of note that its position between the percentage of combustible in the refuse for units 3 and 8 bears a close relation to its position between the temperatures of preheated air for units 3 and 8. The author feels that this relation follows almost too closely to be a matter of chance and that there is apparently a very definite relation between reduction of combustible in the refuse and increase in the temperature of preheated air.

The author appreciates the fact that an accurate determination of the combustible in the refuse is very difficult to obtain and because of this fact use is made of a small ash grinder. All the ash from a boiler test is run through this grinder and reduced to very fine particles. The entire ash discharge from the test is then quartered to a laboratory sample by the method of the Bureau of Mines and is analyzed. In the test of unit No. 3 there are two values for approximately the same fuel rating. These are from two separate tests which were made while the boiler was being operated first from a low to a continually higher rating and then back to a lower rating.

The performance of these preheaters must not be applied directly to different types of boiler installations without due allowance for changed conditions. A higher temperature of exit gas from the boiler or economizer with the same air-preheater surface area necessarily results in a higher stack-gas temperature, but it also results in a greater heat transfer through the air preheater.

The data on performance seem to indicate that the plate heater is not continually as effective for a given surface area as the tubular heater. This, however, may be due to the particular design of the heaters, and must not be taken as a condemnation of the plate heater or as an indication that the plate heater will always perform less satisfactorily.

Without stating any definite conclusion, the author's personal feeling is that the plate heater will always be more difficult to keep clean, and for this reason is likely to show a less satisfactory heat transfer than the tubular heater which may be more easily cleaned. The Ljungström heater is even less difficult to keep clean than the tubular heater, and for this reason will show a more uniform heat-transfer rate under continuous operation than either of the other types of heaters. The performance of the Ljungström heater in every-day operation, however, is likely to be misleading since the air leakage from the forced-draft fan into the flue gases through the rotor, due both to air entrainment and to pressure leakage, reduces the measured temperature of the flue gas below the actual temperature of exit gas from the rotor, and leads an operator erroneously to feel that the flue-gas temperatures are low.

Selecting a Power and Heat Supply for Industrial Plants

Basis on Which Schemes Used to Supply Heat and Power to Industrial Plants May Be Compared—Curves Illustrating Power and Steam Demands of Different Industries

By MARCUS K. BRYAN,[1] BOSTON, MASS.

SEVERAL schemes may be used to supply the heat and power demands of industrial plants. The object of this paper is to point out some of the principal factors influencing the choice of a scheme, and to draw certain general conclusions which may serve as a guide in judging the proper application of different types of power supply to industrial plants.

The paper will discuss:

1 A basis upon which schemes may be compared for the selection of one of them
2 The schemes most commonly used to supply heat and power to industrial plants and the fundamental differences between them
3 Curves illustrating power and steam demands of different industries.

For a power-plant scheme to be acceptable in a manufacturing plant, it should be commercially efficient, that is, it should justify the investment in it.

Other considerations aside for the moment, the plan should be selected upon the basis of the financial return on the investment. The most desirable plan for supplying power and heat is therefore not necessarily the plan which furnishes a reliable supply of each at the lowest total yearly cost, but is probably the one, reliability considered, which supplies power and heat at the cost which makes the investment most profitable. Of two schemes supplying power and heat at different prices, the one costing the less to operate and maintain is the better if the investments in them are equal.

If the investments in the schemes are unequal, then the difference between the costs of supplying power and heat should amount to an attractive return on the difference in the investments, so as to justify the plan having the smaller annual expense; otherwise the plan costing the less to install will probably be the more attractive. If the saving does not amount to an attractive return on the investment, the plan with the smaller annual cost is then not so desirable as the one costing less money to install. To make such comparisons, it is necessary that investment costs, total annual costs, and savings be determined and expressed in terms of money.

Total annual costs should include all operating expenses and all of the fixed expenses. Operating expenses are controlled by the demands both for power and for heat, and for this reason it is generally safer to deal with the combined cost of power and heat rather than with their separate costs. The costs of power and of heat are interesting items and they are necessary if departmental charges are made, but for the purpose of comparing power-plant schemes these individual costs are not needed, and it is advisable not to use them. In most power-plant schemes, and particularly those using non-condensing or extraction-type power units exhausting into manufacturing processes, it is difficult to be sure that the costs of power and heat are accurately separated. If the separation is not accurate, a comparison of unit power costs or unit heat costs from two schemes is likely to lead to a false conclusion, and since the combined costs of power and heat can be estimated with an assurance of reasonable accuracy, they are to be preferred in making comparisons.

The reliability of the scheme selected is of prime importance. The production of manufactured product depends upon reliability in the power plant, and a failure to supply either power or heat for only a short time may cause losses in production or in the spoilage of goods, the value of which would be greater than any saving possible in the power plant. To be thoroughly reliable, the source of power and heat should deliver a constant quality of heat and power in any quantity as demanded. This is perfection in reliability, and although it is not realized in practical plants, either industrial power plants or public-utility plants, it will probably be present to a different degree in the schemes considered and affect their values correspondingly.

In addition to financial return and reliability, careful thought should be given to the flexibility of the schemes, or their adaptability to reasonable expansion and ability to meet variations in the load.

The latter, operating flexibility, enters into the cost comparisons by affecting investments and operating expenses. The effect when operating flexibility is provided is to increase the investment, and because of this the cost comparisons may favor a scheme with little flexibility. Flexibility for growth may or may not enter the cost comparisons. The extent to which it should be provided is in most instances uncertain, depending largely upon the future development of the factory. In the event of plant growth, a scheme lacking in flexibility may cause a loss of invested capital, for if it cannot be continued or enlarged at a reasonable cost, it may have to be abandoned and replaced. Difficulties in expansion frequently result from the location in which the installation has been made, but the scheme or type of equipment used may be at fault. Occasionally a scheme will make savings large enough to repay its first cost in a short time, thereby justifying its selection even though expansion is not practical; but generally if a scheme cannot be reasonably enlarged to follow plant growth, it is to be avoided.

Another important consideration is that of the sustained use of the power plant, or its load factor for a period of years. The daily load factor at any time is determinable, but the load factor now being referred to is indeterminate, being dependent upon the "ups and downs" in the business of the factory which the power plant serves. If business continues and the factory needs for power and heat are maintained to the extent considered when estimating the schemes, then the savings should be about as the cost comparisons indicate; but if business decreases and with it the needs for power and heat decline, or if the nature of the business changes and reduces the use of power and heat, then the estimated savings will probably be reduced. There is no other way to take account of this chance than to discount the expected savings in the light of the best business judgment. When comparing schemes for power generation, this element of chance enters about equally into all of them, but when comparing costs of generating power with those for the purchase of power on the contract basis, it should be remembered that the maximum loss with purchased power, resulting from partial operation or reduced power needs, can be definitely fixed by the minimum guarantee specified in the power contract. The conditions of the individual case will dictate to what extent estimated savings should be discounted, and in general the more hazardous the business, the greater should be the discount.

The basis, then, upon which schemes can be compared and a selection of one of them made, is the savings which would result from the scheme and the earnings which may be returned on the investment in it, all modified by judgment of the reliability, flexibility for growth, and sustained use of the scheme.

Usual Schemes

The make-up of the industrial power station is a combination of a boiler plant—necessary in all designs as a heat supply—and a power supply provided by one or a combination of the following methods:

1 Condensing steam power, either
   a generated in the industrial plant, or

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Contributed by the Power Division and presented at the Providence Meeting of the A.S.M.E., Providence, R. I., May 3 to 6, 1926.

b generated in a public-utility plant and purchased by the industrial plant; or

2 Non-condensing steam power with the exhaust steam wholly or partly used in the processes and building heating system, or

3 Hydroelectric power, which is not considered in this paper.

The function of the boiler plant is to convert the energy of the fuel into heat energy and to transfer this to water and steam ready for use. The design of the boiler plant is influenced largely by the character of the load, the type of operators available, and the costs and availabilities of fuels, rather than by consideration of the uses to be made of the steam, since improvements in fuel burning and in the design and operation of equipment are effective to reduce waste in the boiler plant, regardless of the uses made of the steam. Boiler pressure is unquestionably of importance in its effect upon the performance of power-generating units, but nevertheless the problem in arranging a source of power and heat is primarily one of using the heat in the steam to best advantage.

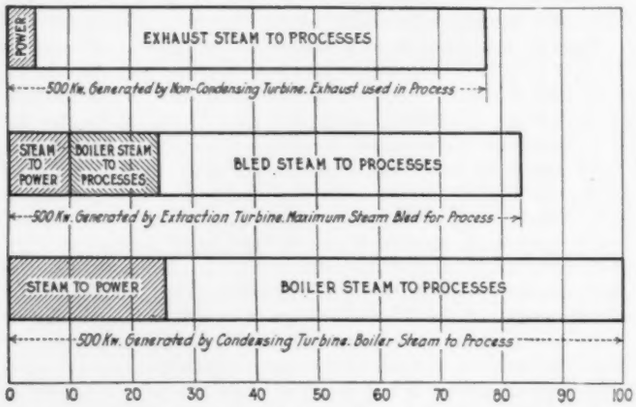

FIG. 1 DIAGRAMS SHOWING RELATIVE COAL CONSUMPTION OF INDUSTRIAL POWER PLANTS

(Power and process-steam loads the same in each case.)

Steam-turbine development and electric-power generation and use have had an important influence upon the make-up of the industrial power station. The development of high-economy condensing turbines of large capacity has helped public-service power to make a stronger bid for the industrial load, while the development of the bleeder and non-condensing turbines has made it possible for many industrial power plants to supply their product more economically than heretofore. The effect in each case is a fuller utilization of the heat in the steam.

Maximum utilization is possible with a non-condensing power-generating unit, while with the bleeder-type unit and the condensing unit the possible utilization decreases in the order named. It is evident that the latent heat of the steam exhausted into the condenser by a condensing turbine must be carried away in the circulating water, while the exhaust from a non-condensing unit in an industrial plant might all be used in the manufacturing processes with no loss of heat. Under such conditions the coal used to make power in the non-condensing unit will be less than the straight condensing steam-power station throws away in the circulating water.

To illustrate this, assume a non-condensing plant with a 50-lb. water rate, a 60 per cent boiler efficiency, a 9-lb. evaporation, and 14,000-B.t.u. coal. This plant would generate one kilowatt-hour and supply the manufacturing processes with 42,000 B.t.u. in the exhaust steam, using 78,000 B.t.u. of coal. To supply the processes direct from the boilers would require 70,000 B.t.u. of coal. The difference in coal used, 8000 B.t.u., is then the amount chargeable to the non-condensing generation of one kilowatt-hour of power. The latent heat of 9 lb. of condensing-turbine exhaust is about 8000 B.t.u., so unless the condensing turbine has a water rate better than 9 lb., the loss in the circulating water will be greater than the cost of power made in the non-condensing unit.

The utilization of heat by the condensing plant is for power generation only, while the non-condensing plants and the bleeder-type plants divide the utilization of heat between power generation and process work and use the heat not converted to power in the processes instead of losing it as the condensing plant does in the circulating water. This advantage in the utilization of heat which the industrial plant may have over the straight condensing plant, by virtue of the combination of power and heat requirements, is fundamental in limiting the efficiencies of these plants.

The modern steam-generating stations are taking advantage of this by bleeding the main units for feedwater heating and sending less steam to the condenser.

To illustrate the difference in one case between the non-condensing, bleeder, and condensing plants, the diagrams in Fig. 1 were prepared. They represent the distribution of the fuel burned in making 500 kw. of power and in supplying a given amount of heat when using non-condensing, bleeder-type, and condensing units. In each case the same boiler plant is used and the power and process steam loads are equal.

In practical applications the comparisons may not be so favorable to the non-condensing unit. In the illustrations used previously the heat needs of the processes coincided with the demands for power and at all times were equal to the heat thrown out in the exhaust, thus making it possible to generate all power non-condensing and to use all of the exhaust steam. Such a condition is unusual since the relation of heat and power demands ordinarily varies from hour to hour. At one time the uses for heat may be less and at another time greater than the heat in the exhaust steam from non-condensing units making all of the power.

In most plants this relation is constantly changing in a manner not to be anticipated, but to avoid waste and to most completely utilize the heat it is necessary that the power-plant scheme be set up to follow these variations.

A power supply combining condensing and non-condensing units, so arranged that the loads on each vary as the demands for process steam change, will do this. The exhaust from the non-condensing unit would supply the process-steam needs, and this unit would carry a load proportional to these steam demands, with the balance of the power load being carried on the condensing machine. Such conditions are fulfilled with either the bleeder-type unit which combines a non-condensing and condensing unit in one machine, or by the combination of non-condensing and condensing machines with paralleled generators, or by a non-condensing machine paralleled with a public-utility system.

In some plants having extremely variable process demands, a form of heat accumulator or reservoir may be a desirable addition to the equipment. The extreme demands for heat can be drawn from this, and heat can be stored here when the process demands are light.

This reservoir may take the form of a steam accumulator or, more commonly, in this country at least, of a hot-water storage, which is particularly worth while in plants using large quantities of warm water—for example, woolen mills. The hot-water storage may be used in some of the following ways:

1 The non-condensing unit may exhaust directly into the water storage through noiseless heaters with the steam supply under control of thermostats; or

2 The non-condensing unit may exhaust through a closed heater, the water being pumped through it into the storage and being controlled thermostatically; or

3 The condenser circulating water may be controlled for a given temperature and be collected in the hot-water storage tank.

Plant load conditions will make some one or a combination of the aforementioned schemes most desirable. The non-condensing power unit is thermally more efficient than the bleeder or condensing type when all of the exhaust steam is used to displace steam otherwise taken directly from the boilers for process work, and the bleeder and condensing types follow in order. Commercial efficiencies, or financial efficiencies, do not necessarily follow in this order. These are measured, as previously mentioned, by the comparison of investment costs and savings. There are, however, some outstanding influences which affect the various schemes and roughly indicate their probable usefulness.

To recognize these factors as applicable to any particular plant, it is necessary to know something of the relation of the power

and heat requirements which are to be supplied. Although a full knowledge of this relation is the only security for a complete and accurate study, a general knowledge of it is frequently sufficient to direct a preliminary investigation.

The amount of non-condensing power available in the steam which is used in process work is of first importance. This will depend upon the boiler pressure and the pressure at which the processes must be supplied. In existing plants both of these are fixed. In new plants there is some latitude in the boiler pressure.

The curves in Fig. 2 show how power output is affected by change in the pressure drop through a non-condensing turbine.

Fig. 3 illustrates the power load curve of a plain-goods cotton mill. It shows also the power which could be made non-condensing from the process steam used in the mill. The building heating load is variable, and about 90 per cent of the heating is done after mill hours. Obviously, then, the generation of non-condensing power in such plants is not to be seriously considered, and the power sources to consider are purchased power and condensing steam power.

In general it may be said that plants having steam and power loads like those of plain-goods cotton mills will find it no more expensive to purchase power than to provide it in some other way. Table 1 gives a comparison of power and heat costs from two sources supplied to plain-goods cotton mills. Plant "A" is a supply

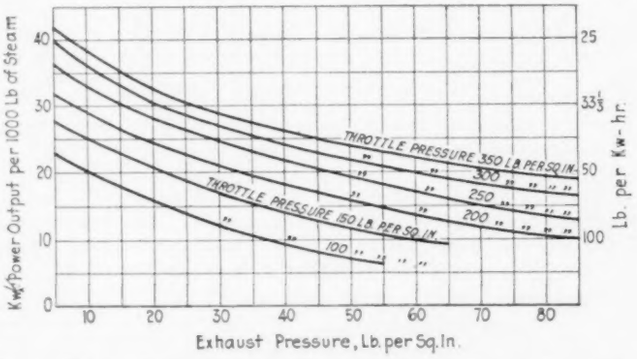
Kw. Power Output per 1000 Lb. of Steam
Lb. per Kw-hr.
Exhaust Pressure, Lb. per Sq. In.
THROTTLE PRESSURE 350 LB. PER SQ. IN.
300 " " " "
250 " " " "
200 " " " "
THROTTLE PRESSURE 150 LB. PER SQ. IN.
100 " " "

FIG. 2 POWER OUTPUT OF NON-CONDENSING TURBINE AT DIFFERENT THROTTLE AND EXHAUST PRESSURES

from condensing steam turbines, and Plant "B" is a purchased-current power supply. In plant "B" a small boiler plant is included for the heat supply. The cost of coal is taken as $7 per long ton, delivered. The purchased-power costs are based on the current rates of a prominent New England public-utility company.

TABLE 1 COST OF POWER AND HEAT IN PLAIN-GOODS COTTON MILLS

(Mills operating 48 hr. per week, or 2400 hr. per year.)

	Size of plant in kilowatts			
Investment	1000	2000	3000	5000
Plant "A"—Boiler plant and turbine plant	$178,000	$304,000	$390,000	$665,000
Plant "B"—Heating plant and substation	41,000	60,000	68,000	98,000
Difference in investment	$137,000	$244,000	$322,000	$567,000
Operating Cost				
Plant "A"	$ 36,300	$ 62,700	$ 92,000	$127,300
Plant "B"	44,200	81,000	116,400	186,400
Fixed Cost				
Plant "A"	$ 22,300	$ 38,000	$ 48,800	$ 83,200
Plant "B"	5,000	7,500	8,500	12,300
Total Cost of Power and Heat				
Plant "A"	$ 58,600	$100,700	$140,800	$210,500
Plant "B"	$ 49,200	$ 88,500	$124,900	$198,700

These comparisons are made for new plants. They show favorably for purchased current, and the difference in investments is sufficiently large so that the cost of current could be considerably greater than is taken in the comparison before an acceptable earning would be made on the money invested in the turbine plant. With a different coal price and a different rate for purchased current, the costs may favor the condensing plant, and it is well to investigate each problem.

In making comparisons of existing plants with purchased current the results would probably be reversed, since the installation of purchased current would call for the abandonment of investment already made in a serviceable plant. It is to be noted that the operating costs are more with purchased current than when power is generated.

Fig. 4 illustrates summer and winter loads of a plant which uses steam for heating throughout the twenty-four hours of the day and in addition uses a small amount of process steam. These loads are more favorable to power generation than those just described. The power which could be made non-condensing from the steam used in processes and building heating is shown for a winter day by the dashed curve. This amounts to about 30 per cent of the total power needs and is worthy of consideration. For this plant

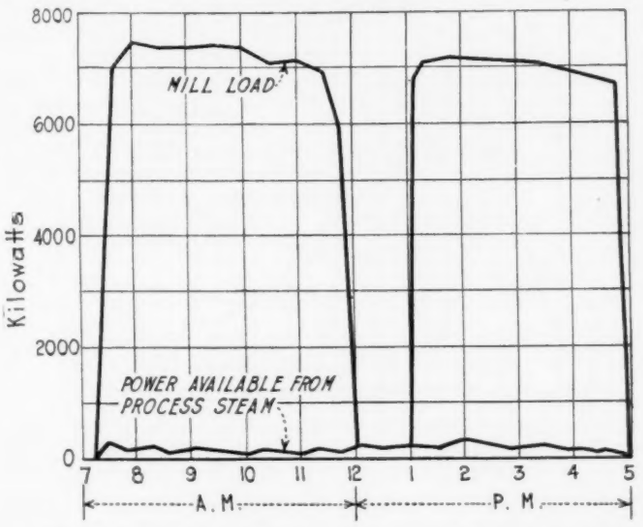

FIG. 3 POWER LOAD CURVE OF A PLAIN-GOODS COTTON MILL
(Mill hours, 48 per week; building heating 90 per cent after mill stops at 5 p.m.; building heating load, 4500 to 24,000 lb. per hr.)

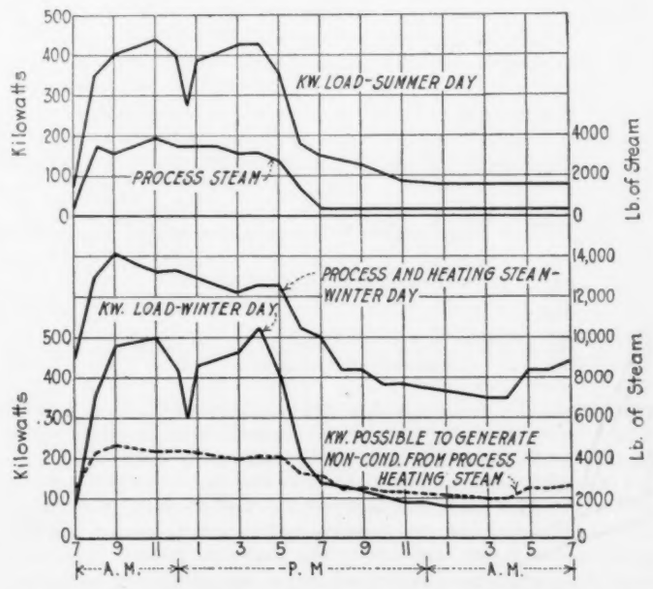

FIG. 4 STEAM AND POWER LOADS OF A PLANT USING STEAM FOR HEATING 24 HR. A DAY AND IN ADDITION A SMALL AMOUNT OF PROCESS STEAM

the bleeder-type unit or the non-condensing unit supplemented with purchased power could be considered and compared with purchased current.

A preliminary study of this problem will illustrate some of the usual handicaps of the industrial plant.

The first of these is the size of the generating unit, in this case about 250 kw., for a non-condensing machine, the unit cost of which will be higher than for a larger machine. Labor in operation will cost as much for a small machine as for a large one, and more than if power is purchased. If the unit is to be installed in an existing plant, it is likely that the steam piping to the building heating

system and the processes will be found to have been built to distribute steam at boiler pressure to reducing valves located in the various rooms of the factory. Such a piping system would not be large enough to distribute low-pressure steam from the turbine, and the installation of a low-pressure piping system would be required and add another item of investment with its burden of fixed costs. The cost of low-pressure piping for small machines may amount to thirty or forty dollars per kilowatt.

Because of these handicaps the plant shown in Fig. 4 could save only about $2200 a year from the present costs with all power

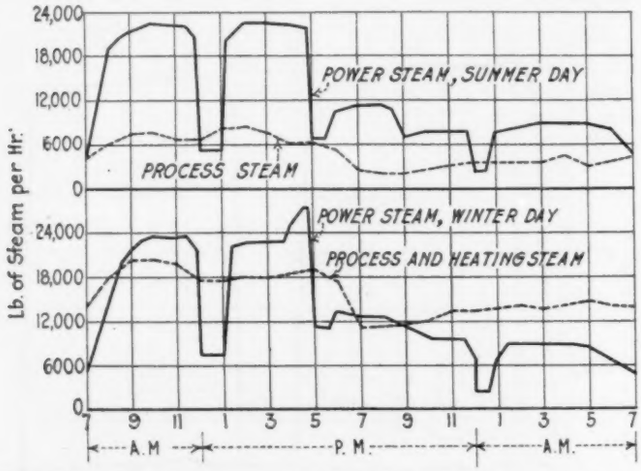

FIG. 5 STEAM LOAD CURVES OF PLANT WITH NON-CONDENSING POWER UNITS

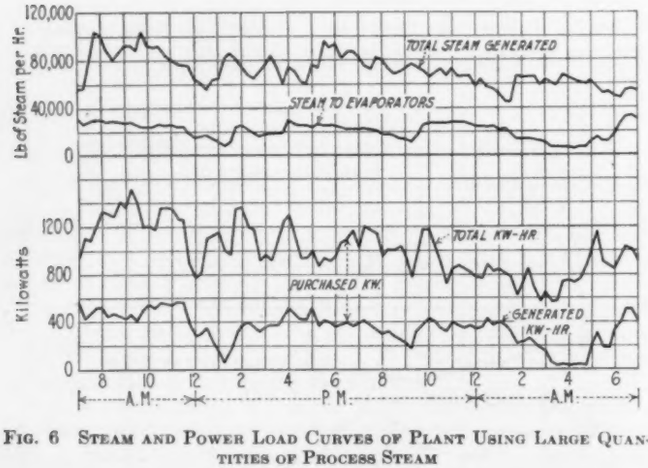

FIG. 6 STEAM AND POWER LOAD CURVES OF PLANT USING LARGE QUANTITIES OF PROCESS STEAM

purchased. To make this saving an investment of about $30,000 would be required, so that what appeared to be an opportunity to improve the power costs was not commercially feasible.

Fig. 5 illustrates summer and winter load curves similar to those of Fig. 4. This plant was built with non-condensing power units which exhausted into the heating system and processes. It has since been changed and part of the power purchased. The non-condensing units are now run and carry just enough load so that no exhaust is wasted to the air. These units are synchronized with the purchased supply, and the latter furnishes the power not made in supplying the low-pressure steam demands. This change produced a substantial saving in power and heat costs. The investment in it was small.

Fig. 6 shows the steam and power load curves of a plant using large quantities of process steam. The curves represent conditions for a typical day. All steam excepting the small uses of a few pumps and the stoker fans is used in process work. The principal use for low-pressure steam is in evaporators as represented by curve *B*. Other and less important uses of low-pressure steam are driers, the building heating system, and boiler-feedwater heating. These uses are supplied from a low-pressure piping system into which all pumps and auxiliaries, as well as a non-condensing turbo-generator, exhaust. This machine runs in parallel with the public-utility system supplying most of the power.

Curve *C* shows the total power load and curve *D* the power made by the non-condensing turbine in reducing the evaporator steam from boiler pressure to 12 lb. pressure.

This installation was made several years ago after a careful study of the process-steam and power loads. The load and pressure conditions were favorable, but there were adverse installation handicaps. The boiler pressure was 175 lb. and the plant operated 24 hr. a day. Before the turbine was installed steam was distributed at boiler pressure and reduced at the process. A low-pressure piping system was therefore necessary before a non-condensing unit could be used. The boiler plant was some distance away from the factory and the electric substation from which power was to be distributed. The turbine installation was made at the boiler house for the purpose of saving attendance and building cost, although this location increased the piping and electric-feeder costs. The installation, when completed, cost about $100 per kw., imposing a burden of $12.50 annual fixed charges

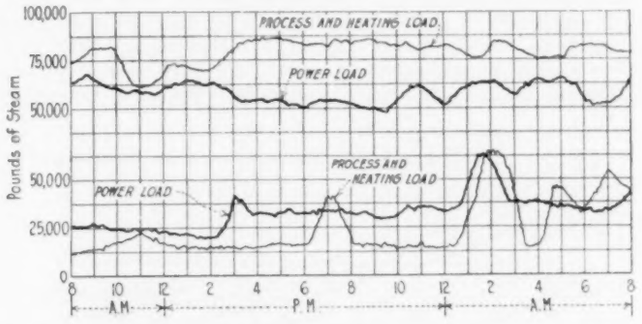

FIG. 7 LOAD CURVES FOR POWER STEAM AND PROCESS STEAM UNDER TWO RATES OF PRODUCTION IN A PLANT USING LARGE QUANTITIES OF PROCESS STEAM

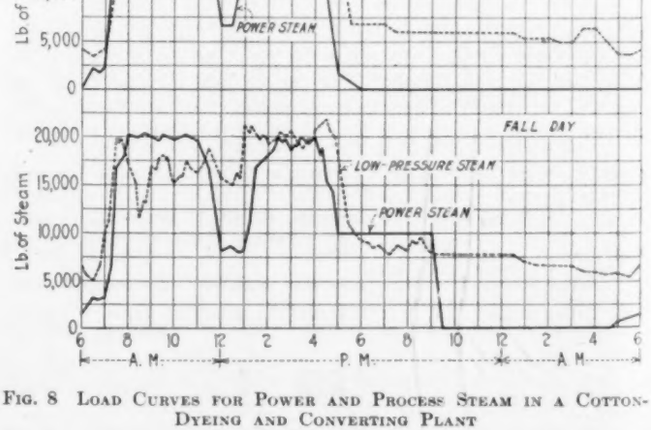

FIG. 8 LOAD CURVES FOR POWER AND PROCESS STEAM IN A COTTON-DYEING AND CONVERTING PLANT

per kilowatt of capacity. As a further obstacle, all power could be purchased for this plant at about $1\frac{1}{4}$ cents per kw-hr., an attractive price. In spite of these handicaps the installation has proved profitable and earns about $12,000 per year, or 25 per cent on the investment over and above all fixed costs. This has been possible for the reason that the machine is used 24 hr. a day. If the use were only eight hours a day, the yearly saving would be reduced to about $2000.

The unit power costs for this installation with a 24-hr. load and an 8-hr. load may be compared with interest. They are given in Table 2.

These figures illustrate the effect of fixed charges on the power cost of the turbine installation, and show the comparative costs of purchased power and non-condensing power in this instance.

Fig. 7 show the load curves for power steam and process steam

TABLE 2 UNIT POWER COSTS FOR A PLANT USING LARGE QUANTITIES OF PROCESS STEAM

	Cents per kw-hr.	
	24-hr. load	8-hr. load
Cost of power from turbine[1]	0.40	1.00
Cost of purchased power:		
a Used with turbine	1.467	2.66
b If all power had been purchased	1.223	2.05

[1] Fixed costs are 70 per cent of total for 24-hr. load and 84 per cent for 8-hr. load.

under two rates of production in a plant using large quantities of process steam. The upper curves show loads at a high rate of production and the lower curves are the loads corresponding to a low rate of production. It will be noticed that the relation of steam for power and for processes changes with production, and that there would be considerable waste of exhaust steam if all power were made non-condensing when the rate of production is low. Obviously the proper scheme for this plant is a compromise between the two conditions illustrated, and a detailed study of the load changes should be made before a selection is attempted.

Fig. 8 shows the load curves for power and process steam in a cotton-dyeing and converting plant. The total requirements for steam in process work are about equal to the requirements for power steam, although at various times in the day they differ considerably. In these and similar plants the bleeder-type unit can frequently be used to advantage. Such plants use large quantities of warm water. This requirement makes a heat reservoir, or hot-water storage, practical to level out the inequalities of the process and power steam requirements.

In the majority of the illustrations cited the non-condensing units have appeared at a disadvantage, and the impression may have been created that these units are unworthy of consideration. This is not the fact. The illustrations were chosen to point out the handicaps which these machines must overcome.

No very definite conclusions are possible regarding the selection of a source of heat and power for an industrial plant. The public utility should be, and generally is, able to sell power to industries to their advantage as long as the needs for low-pressure steam are small. If the industry has a use for low-pressure steam heat large enough so that from 15 to 20 per cent of its power can be made as a by-product of heat supplied to the processes, then schemes to make this power should be considered. Studies of these propositions should be based on carefully selected data, and the total costs of all power and heat as made in different ways should be compared and analyzed.

Recent Developments at Colfax Station

IN THE issue of MECHANICAL ENGINEERING of January last, on page 39, there was printed, in slightly abridged form, a paper presented at the 1925 A.S.M.E. Annual Meeting by Charles W. E. Clarke, dealing with the Colfax Station of the Duquesne Light Co., Pittsburgh, Pa. In this paper were given the test results of the 3-A element of the station which showed net heat rates of 12,750 B.t.u. per kw-hr. at 30,333 kw., 13,021 B.t.u. per kw-hr. at 22,400 kw., and 14,200 B.t.u. per kw-hr. at 15,050 kw. A brief history of the physical plant involved in the original station, and in the unit extensions Nos. 1, 2, and 3, was given, with data on boiler and turbine outages and condenser cleaning. The author showed that the total cost of the station had been to date $115.80 per kw. for the 190,000 kw. of installed capacity, and predicted a total cost, when the fourth unit was installed, of $107.50 per kw. for 270,000 kw.

In the discussion following the presentation of the paper, F. O. Ellenwood[1] wrote that the author would have made his paper even more valuable had he given the additional cost incurred by the installation of heaters in 1925, thereby permitting a direct comparison of the reduced expenditure with an additional investment. He also regretted that the author did not make clear in the tabulation of the data whether the pressures were absolute or gage.

Professor Ellenwood was inclined to question the statements relating to the recovery of heat losses by using the condensate as a cooling medium for the generator air coolers, transformers, and turbine-bearing oil, and to condense the steam from the steam-jet vacuum pump. Concerning Fig. 4, he said there was a question as to whether this showed the system as the designers had planned it, or as it had been obtained by test. If the latter, he wondered why it did not agree more closely with the test results.

H. W. Leitch[2] also commented in writing, stating that the extension of Colfax was of particular interest on account of the opportunity it presented of comparing the general performance of a modern powdered-fuel installation with a comparatively modern stoker installation. It was unfortunate, he said, that the detailed test figures on the third section gave results only as of the boiler nozzles, resolving itself into a test of turbines and heat balance. He felt that the overall load B.t.u. per net kw-hr. delivered under conditions of full load of 12,752 B.t.u., although only for three hours, showed remarkable heat recovery and good turbine performance. Assuming an overall boiler efficiency of 85 per cent as against approximately 80 per cent given as a maximum in Fig. 5, 15,000 B.t.u. input per kw-hr. output, or 16,000 B.t.u. at 80 per cent boiler efficiency was shown.

As a check against this Mr. Leitch mentioned a 24-hr. run made on one Hell Gate section consisting of a 35,000-kw. turbo-generator and three 1590-hp. boilers equipped with economizers, superheaters and water-tube side walls, all installed in 1923, during which period the unit had generated 639,000 kw-hr. with a weighed coal consumption of 643,000 lb., representing a consumption of 14,080 B.t.u. per kw-hr. generated. This run was made under conditions of 66-deg. fahr. circulating-water temperature, 8 deg. higher than at Colfax. It was expected, he said, that a run of this sort under winter conditions of low auxiliary power and high vacuum would indicate an increased efficiency to about cover a proportionate station loss, and the result would indicate the production of a kilowatt of net station output for less than a pound of good coal.

Joseph A. Bennett[3] wrote that almost invariably when a plan was discussed with both stoker and pulverized-coal installations a comparison was made between the results obtained with the two systems. As a rule, he said, the stoker was rather an obsolete type, and the conclusion reached was that stoker firing was quite an inferior system as compared with the modern pulverized-coal system installed. He pointed out that this was particularly conspicuous in the operating results shown in Fig. 5, where there was a sharp drop in the efficiency when poorer grades of coal were used. It seemed to him that in making a fair comparison, a stoker with proper equipment to offset immediate objections should be considered. In case of a coal strike, he said, the loss almost invariably increased rapidly in the ordinary type of ashpit considered. With a properly designed ashpit, meaning a very deep ash pocket with air at the bottom part of the bridge wall, the combustible in the ash ran ordinarily to give a loss of from 0.3 to 0.5 per cent of the total heat value of the coal.

Mr. Bennett felt that this result might seem rather extraordinary to those who had not been in touch with more recent developments of the stoker. The deep ashpit had not only reduced combustible in the ash but had also offset poor operation, he said. As a definite example of that, he mentioned an installation with an ashpit about 5 ft. deep which had been given extensive tests resulting in certain efficiencies. Later, under very much the same conditions but with a smaller boiler, additional tests had been run and the results showed that the gain in efficiency, due to a large extent to the recovering of the ash at high rates of driving, was about 6 per cent at 300 per

[1] Professor of Heat Power Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

[2] General Superintendent of Power Plants, United Electric Light & Power Co., New York, N. Y. Mem. A.S.M.E.

[3] Assistant Engineer, American Engineering Co., Philadelphia, Pa. Assoc-Mem. A.S.M.E.

cent of rating. At 400 per cent it was not possible to get the result exactly, but the gain amounted to from 8 to 10 per cent. Later figures on the more modern system, he said, gave 87 per cent efficiency for the boiler alone at approximately 400 per cent of rating.

R. J. S. Pigott,[4] who also contributed a written discussion, felt that the paper was particularly valuable as showing the tremendous effect of the multiple-bleed-point regenerator system on modern turbines. The tremendous decrease in B.t.u. rate was due, he said, to the extremely new economical section. The effect of this, he pointed out, would increase as the amount of kilowatt-hours relative to the total amount of kilowatt-hours increased, ultimately reaching the B.t.u. rate of the new section.

Mr. Pigott mentioned a station similar to the one described by the author, in Toronto, that had been running since April, 1925, in which the physical layout was very much like that of the new sections of the Colfax Station. While, he said, test results were not available, sufficient data were on hand to indicate a net B.t.u. rate of something under 15,000, although this optimistic figure had not been used in computing the probable cost. At the time of preparing his remarks, the station was using 16,000 net B.t.u. per kw-hr. and the rate was continually going down. In this particular installation the rate of driving the boilers had been carried a little higher than in the Colfax station and other powdered-coal plants.

The first layout had been designed for a maximum boiler operation of 300 per cent of rating for the load turbines, with the possibility of being forced to 400 per cent of rating at times of boiler outage, figuring on one boiler out of four. This condition, he explained, would of course apply to the first two units installed, and would be lowered as the number of units in the station was increased. At this high load the plant had given trouble due to excessive smoking. In the plant in which this had occurred the water screens were used to a larger extent than ever before.

The question of air distribution, he said, came up in the handling of a powdered-coal fire. The mere large volume of these furnaces was not sufficiently reasonable to give good combustion without smoke, he explained, unless the most careful attention was given to the control of the fires. He believed that it would not have been possible to operate this plant satisfactorily without combustion control. During the period in which hand control was used, excessive trouble from smoking had occurred. It had been found, however, that a great deal of the smoke could be avoided by studying the air supply. Above 250 per cent of rating smoking had not yet been eliminated, he said, even with automatic control, although he saw no reason to suspect that smokeless combustion would not be achieved. It seemed to be necessary to furnish more primary air in order to shorten the flame. In any case, he said, the flame must be kept away from the boiler surfaces if smokeless combustion was to be attained.

The comparison of heat balance was becoming a difficult matter, Mr. Pigott said, no two stations built having the same heating arrangements. In due course, he pointed out, a study would have to be made to ascertain which arrangement was the most efficient, and the changing of heat-balance systems stopped. In the station mentioned an attempt had been made to raise the feedwater temperature by bleeding, using such means as would not cramp the bleeding cycle with the temperature at 380 deg. fahr. At the time, he said, it was only carried at 360 deg. fahr. due to troubles caused by casing expansion on the boiler-feed pumps, adding that most boiler-feed pumps were not safe for higher temperatures than 300 deg. fahr. If the temperatures were higher, the pumps should be redesigned for safety. The feedwater temperature, he explained, was constant within 5 deg. fahr. or more without any hand manipulation, so it was evidently possible to get a heat-balance system automatically without adjustment.

A. K. Bak,[5] in a written discussion of the paper, called attention to the author's statement that while the operating pressure was kept the same in the third unit extension, the steam temperature was increased from 600 to 650 deg. fahr., and said that since several other stations had gone to 700–725 deg. fahr. it would be of interest to hear the reason for not going higher than 650 deg.

Considering the fact that the original installation contained 60,000-kw. three-element units, whereas the new machines apparently were 35,000-kw. single-barrel units, and in view of the general trend toward larger units, he wished to know the reason for the change to the small unit.

Mr. Bak expressed interest in the fact that whereas the side walls of the furnaces were protected either by screen tubes or by air cooling, the furnace bottoms had both, and wondered whether or not the added complication of hollow bottoms and air cooling paid for itself. Reference was made to the statement that the high heat rate from May to September, 1922, had been due to burning coal of widely different grades and characteristics. Using the curves of Figs. 5 and 7, and comparing the averages for these four months with the yearly averages for 1922, he said, one found that whereas the boiler efficiency was about 2.9 per cent lower, the B.t.u. per kw-hr. net increased some 7.5 per cent, and for the two months of July and August the boiler efficiency was about four per cent lower than the yearly average, but the B.t.u. per kw-hr. net increased almost 12 per cent. Although the auxiliary power consumption undoubtedly would be greater during the above-mentioned period, he pointed out, it would hardly account for the difference, and it appeared that there must have been some other reason besides the widely different grades of coal.

Table 1 of the paper gave the results of three tests on one of the units. A closer study of this table revealed some very surprising information, he found. The back pressure at the board was from 0.2 to 0.37 in. Hg higher than that observed in the cellar. It was not stated where in the condenser the pressures had been measured, but one must assume, Mr. Bak said, that the difference indicated the drop through the condenser, which seemed very high. It appeared that the same barometer reading was used in determining the two back pressures without taking into account the difference in elevation.

Mr. Bak also pointed out that the evaporator vapor temperature was lower than that corresponding to vapor pressure—in other words, the evaporator produced supercooled vapor. He felt that the temperatures and pressures as recorded checked very poorly, and as another example, mentioned the fact that heater No. 3 showed a higher drain temperature than that corresponding to the pressure in the heater. With heaters one usually found a certain relation between terminal difference and load, he explained, adding that the readings presented showed no consistency whatever. He was interested in the fact that the last heaters received steam of high superheat (up to 200 deg. fahr. superheat) and that the water was heated to a higher temperature than that corresponding to the pressure in the heater.

He further pointed out that while on load and water measurements the author reported both indicator and integrator readings, he did not state which had been used in the calculations.

The author, in closing, referred to Professor Ellenwood's question as to the cost of bleeder heaters, and said that it was not possible to pick out any one item in a large development such as Colfax Station, except for comparative purposes, and predict that it would or would not pay. The installation of bleeder heaters in a heat cycle immediately made necessary, if proper economies and reliability were to be secured, the consideration of other means of auxiliary power supply; and if auxiliary shaft-driven generators such as at Colfax were used, the actual cost of the turbo-generator unit was increased, but there was a greater decrease in cost over the old auxiliary power situation made possible by the omission of house turbines, etc.

In the case of the Colfax four-stage bleeder system, at 50 per cent load factor, the return on the investment would be somewhere in the neighborhood of 25 per cent on the actual cost of the bleeder system.

The pressures given in the heat-balance diagrams were absolute. The difference between the calculated figures on the diagram and the test figures gave a good comparison of the accuracy with which the designers had been able to predict the functioning of this system.

As to the question on the 29 deg. fahr. which had been added to the hotwell water by the generator air coolers, oil coolers and transformers, the addition of this heat to the cycle reduced the amount of steam which could be bled at the first bleed point by an amount

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[4] Public Service Production Co., Newark, N. J. Mem. A.S.M.E.

[5] With Municipal Power Plants, Copenhagen, Denmark. Mem. A.S.M.E.

equal to 29 deg. elevation of the condensate. This in turn would show a corresponding increase in condenser loss due to this 29 deg. addition of temperature in the condensate. It would have been better for thermal efficiency not to have had this temperature added to the condensate, but the safe and reliable operation of apparatus secured by providing clean cooling water at these points overbalanced any efficiency which might be lost.

With reference to Mr. Leitch's comments, it should be noted that the average efficiency figures given covered only two of the new pulverized-fuel boilers with fourteen stoker-fired boilers. Two of the stoker-fired and the two pulverized fuel-fired boilers were equipped with air heaters. The actual efficiency of the new pulverized-fuel boiler plant was considerably higher than that indicated by the average figure.

The author realized the difficulty in comparing power-station costs, as had been pointed out by Mr. Leitch. The cost given in the paper covered all costs with the exception of land.

The question had been raised as to the reason for the variation of feed temperature between 300 and 350 deg. at varying load. A bleeder heater system was practically automatic, the work being done by the induction of steam into the heater system, and the steam flow into the various heaters naturally depended on the pressure condition existing at the bleeder points in the turbine, which in turn was affected by load.

In reply to Mr. Pigott's comments, the author said that his paper on heat balance given two years ago had stated that Colfax had a boiler-nozzle heat rate of 14,200 B.t.u. If that were compared with the present boiler-nozzle heat rate of 12,752 B.t.u., the difference would be the improvement due primarily to the different heat cycle.

Referring to the regulation of the pulverized-fuel plant, the author said that the Colfax Station was having some difficulties along the lines mentioned by Mr. Pigott, this being evidenced by smoke at times of improper air distribution; but it was felt that experience would straighten out this matter. As far as primary air supply for the burners was concerned, arrangements were being made to use more air at this point, and he would not be surprised if as much as 40 per cent of the total air was ultimately used at the burners.

Referring to Mr. Bak's comments, the steam temperature had been raised to a maximum of 650 deg. because the older turbines in the station would not safely operate at a much greater temperature. Further, the low temperatures in the tests shown in Table 1 were due to the small number of boilers operating with the larger superheaters as compared with the other low-temperature superheaters in the station.

As to the reason for changing from the three-element, 60,000-kw. unit to the two 35,000-kw. single-barrel units, this had been entirely a commercial matter with the manufacturer. The new design of turbine had been thought better than the old double unit.

As to the combination of water screens and air-cooled furnace bottoms, the author was entirely satisfied by experience that they were justified.

In reference to the high heat rate from May to September, 1922, Mr. Bak had evidently neglected to take into consideration the fact that Fig. 7 reflected the operation of the entire station, while Fig. 5 showed boiler-room operation only. During this particular period the turbine-room efficiency had also been low. It would be difficult to account for all of these factors except in a general way; the effort to maintain operation under extreme difficulties had probably lowered the morale of the operating forces and affected efficiencies throughout the station.

The results given in Table 1 were obtained from data taken from the regular station instruments, which had been calibrated to an accuracy of plus or minus one per cent. The difference in elevation of points at which condenser pressures had been taken was approximately 25 ft. No attempt had been made to correct for this small difference. The mercury column at the board measured pressure at the exhaust nozzle of the turbine and the cellar pressures had been taken from the condenser hotwell. Considering the size of the unit, the difference in pressures indicated were not excessive, particularly as they represented differences in air content as well as friction losses.

It had been found that the point at which the evaporator vapor pressures had been taken gave inaccurate results, and they had not been considered in calculations; the vapor temperatures, however, were correct.

The author could not check Mr. Bak's statements regarding heater temperatures. According to Marks and Davis' tables, which had been used in the calculations, the drain temperatures of both No. 3 and No. 4 heaters were lower than the corresponding temperatures of saturated steam in the heaters. This was due to the cooling effect of condensate in the tubes of the first pass of the heater over which the condensed steam passed before it reached the heater hotwell. The temperature of water leaving the No. 4 heater corresponded very closely to the saturated temperature of the steam in the heater at all loads. Integrator readings had been used for the unit calculations made in Table 1.

Collapse of Metal Ventilating Pipe

IN THE ventilation of long tunnels by means of pipes, the pressure at the blower end is below that of the atmosphere while smoke is being exhausted. This negative pressure decreases in the direction of the open end of the pipe until, at the end, the pressure in the pipe is practically equal to the atmospheric pressure. A ventilating pipe must at all points be sufficiently strong to prevent collapse.

This paper is a discussion of some tests that the author made on steel pipe to determine the negative pressures at which visible distortion began, and the pressures at which the pipes collapsed. "Visible distortion" is of course only relative. Distortion was noted by measuring across several different diameters with calipers. It was recorded as "visible" when it could be detected with the naked eye.

Test pieces were supplied by the W. R. Ames Co. of San Francisco. The pipe would be known as galvanized iron pipe, but is really made of low-carbon steel.

The test pieces of 12-in. pipe were 10 ft. long and were constructed with rolled seams. On the 15-in. pipe the 18- and 20-gage test pieces were 10 ft. long and had rolled seams, and the 14- and 16-gage pieces were made of four sections riveted and soldered, the total length of a piece being 14.5 ft.

The pipes collapsed in the center. After the pipe had collapsed it could be flattened by a differential pressure much less than that needed to collapse it. Results obtained in the tests are as follows:

Diameter, in.	Gage, U. S. standard	Noticeable distortion, lb. per sq. in.	Collapse, lb. per sq. in.
12	22	1.0	3.0
12	20	1.0	3.5
12	18	2.5	7.5
15	20	1.5	3.0
15	18	2.5	4.5
15	16	3.0	7.5
15	14	6.0	Uncollapsed at 10.0

NOTE: Pressures are below atmospheric pressure in pounds per square inch.

If a pipe is distorted by the pressure, the soldered seams are soon broken and the pipe leaks. For this reason it would appear from a study of the table that a factor of safety of about three would be a reasonable one to use in the design of a pipe line.

A pipe that has failed can be forced back into a semblance of its former shape with compressed air. It could never be used again for exhausting, but it would be suitable for blowing. In applying the compressed air a pressure gage should be placed on the pipe and the pressures should be kept well below the value that would cause the pipe to burst. If a vacuum pump is not available, a hose may be connected to the intake of a compressor. The rate at which the air is exhausted from the pipe may be controlled by a valve. (Walter S. Weeks, University of California, Berkeley, Cal., in *Engineering and Mining Journal-Press*, Mar. 27, 1926, p. 522.)

Maintenance and Depreciation of Airplanes and Engines

By ERNEST W. DICHMAN,[1] KELLY FIELD, TEX.

The author presents a careful analysis of the cost of maintenance and depreciation of a number of typical service airplanes at an important Army training field. The analysis is particularly valuable because it covers the operation of a hundred planes over a period of approximately two years. On the basis of his figures he estimates very carefully the probable cost per airplane-hour and per passenger-mile of a possible air-transportation service. The paper also stresses the economic importance of designing aircraft with due regard to ease of maintenance and inspection.

EVER since flight by heavier-than-aircraft ceased to be purely an experiment and entered the realm of utility, the tendency of designers has been to strive for increasingly greater performance. This increase has been mainly accomplished by improved structural design, greater aerodynamic efficiency, and the development of aircraft power plants giving a lower weight per horsepower than formerly. One feature which usually received only slight consideration has been that of maintenance. During the past two or three years the importance of this item has become increasingly apparent, with the result that at present an airplane is not judged entirely by its high speed, rate of climb, ceiling, and other performance characteristics, but also by the amount of work necessary to keep it in flying condition. On special types, such as racing airplanes, it may be permissible to sacrifice ease of maintenance for increased performance, but in the general-utility airplane a few miles' increase in speed does not compensate for a difficult maintenance job. It is a matter of judgment on the part of the designer to secure a compromise between performance, ease of maintenance, and low depreciation, remembering that from an economic point of view both maintenance and depreciation are important.

It is the purpose of this paper to present the results of experience in the maintenance and depreciation of heavier-than-aircraft at the Air Service Advanced Flying School at Kelly Field, Texas. The activities of the Advanced Flying School are confined to training, and training imposes very severe usage upon the equipment. This is particularly true of the engines, landing gear, and lower wings. Therefore experience at this field cannot be applied directly in other aerial operations. Nevertheless, it is hoped that the data presented will be of some value in arriving at an estimate of what it means to maintain a number of airplanes in continuous operation.

Type of Equipment Discussed

The flying equipment of the Air Service Advanced Flying School consists of a number of bombers, single seaters, advanced training planes, and of 100 DH4 two-seater observation planes using a Liberty 400-hp. engine.

The bombers and the single seaters are used only for specialized training, which brings a peak load on them for two months twice a year. Other airplanes at the field are used intermittently as occasion arises. The DH's are used continuously, and discussion will therefore be limited to this type.

Severe Conditions of Maintenance

During the calendar year the Advanced Flying School performed some 18,000 hours of flying in DH4 airplanes alone, with about 80,000 landings, or four landings for each hour of flight. On ordinary cross-country flying the ratio is about one landing for each two hours of flight, so that the ratio of landings to hours flown is increased eight times in training. Most of the landings are performed by students, and it is readily appreciated why a large number of landing-gear replacements are necessary. Poor landings not only affect the chassis but cause a loosening of the entire airplane, making it necessary to check the alignment, tighten wires, and replace fittings. Some conception of the force involved in a bad landing may be obtained by considering that a DH4 airplane weighs 4000 lb. and lands normally at 55 miles per hour. If the pilot levels off too soon the airplane "pancakes" to the ground from ten feet or more, depending upon the inaccuracy of his judgment. The rate of descent in this case would be approximately fifteen feet per second by the time it reached the ground, as the forward speed is greatly reduced, but the wings help to cushion the force of impact. An automobile subjected to the same treatment would not last very long, even if it were dropped squarely on its four wheels and the shock absorbers were built to take the load. With airplanes it has occasionally been the field's experience that where the chassis did not fail under an exceptionally bad landing the fuselage itself would be damaged, usually by the cracking of a longeron.

Complete Overhaul of DH4

It has been the experience of the field in training that after 200 flying hours a DH4 airplane needs a complete overhaul. After eight complete overhauls the airplane is ready to be salvaged. The overhaul consists of removing the fabric from the wings, fuselage, and tail surfaces, and carefully inspecting the fittings and internal bracing of the entire airplane. The wood is inspected for any evidence of brashiness. All spars and longerons are examined to see if the fittings have sunk into the wood, in which case hardwood or metal blocks are used to reinforce these places. The condition of the glue at all joints is examined for evidence of deterioration. After all defects have been remedied and necessary replacements attended to, the various sub-assemblies such as wings and fuselage are made. It is preferable to make these assemblies on a jig, but if this is not feasible, a tape, plumb line, and level must be used. The wings, fuselage, and tail surfaces are then covered and doped, and the entire airplane assembled. The complete overhaul of a DH4 airplane should not require more than 200 man-hours. This figure assumes a sufficient volume of work to permit specialization on certain jobs by the men employed in this work.

Complete Overhaul of Liberty Engine

The overhaul of a Liberty engine should consume not more than 175 man-hours. This includes a complete teardown, cleaning parts, inspection, grinding valves, assembly, and timing. The most economical way to handle a volume of work is to have one crew of men do the teardown and cleaning, another crew do the valve grinding, another the assembly of rocker arms and camshafts, and still another the assembly and timing of the complete engine. The most competent men should be used on inspection and timing. It is the practice in the school to try to get 150 hours of service from a Liberty engine before overhaul. The actual time is less than this, as some few engines, about two per cent, develop defects which require them to be pulled from the airplanes before 150 hours' operation. It is good practice to run each engine for eight hours on the test stand before installation in an airplane. This should allow any trouble, such as poor lubrication, insufficient cooling, or incorrect timing, to develop; and also to permit accurate synchronization of carburetors. If a Liberty engine runs perfectly for ten hours it should run for its full 150 hours without serious trouble. Most major trouble develops in the first ten hours, but many minor defects such as leaky cylinders, fouled spark plugs, or throwing oil may develop later. After 12 overhauls the Liberty engine is considered as ready for salvage. An airplane during the time between its overhauls, or 200 hours, is estimated to use two overhauled engines or close to 300 hours of engine time. The difference in time is due to testing the engine, warming up, and shutting down, all of which serve to give an engine operating time greatly in excess of the airplane flying time. If the airplane is functioning

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[1] 1st Lieut, Air Service; Chief of Inspection, Air Service Advanced Flying School.

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satisfactorily when the allotted 200 hours have been reached and has an engine with only a few hours to run before being pulled down, it is customary to continue flying until the allotted engine time is reached. This allows some airplanes to run 225 or even 250 hours before overhaul.

IMPORTANCE OF INSPECTION

One of the best means of keeping maintenance costs in the continuous operation of a number of airplanes at a minimum is by means of careful and systematic inspection. This does not require an elaborate inspection department involving a high overhead, but it does mean that each crew chief and shopman must be trained to act to a great extent as his own inspector. "Trouble shooters" and regular inspectors must be available to assist him when necessary, but a great deal of work in connection with the maintenance of aircraft is of such a nature that the only real inspection can be performed while the work is being done. The complete airplane and engine should be given a careful inspection each morning by the crew chief.

OUTLINE OF CREW CHIEF'S MORNING INSPECTION

Beginning with the chassis, the tires should be inspected for proper inflation, shock absorbers for condition and correct tension, struts for cracks or checks, fittings for cracks or distortion, wires for correct tension, all bolts and nuts for cotter pins, and all turnbuckles for safetying. The wing cellule should then be inspected: flying and landing wires for proper tension, fittings for cracks or distortion, struts for cracks or checks and proper seating, fabric for condition and tautness, internal drag bracing for tension of wires, and all bolts and nuts for cotter pins, and turnbuckles for safetying. At this point the aileron cables may be examined for frayed strands, with particular attention to the section around pulleys or passing through guides. The top-aileron balance-wire assembly, being difficult to reach, is often slighted but should be looked at carefully, as a broken wire here will render the ailerons useless. The tail surfaces should be examined for secure attachment to the fuselage, condition of hinges and safetying of hinge pins, condition of wires and any evidence of fraying, condition and tautness of fabric, and as careful an inspection as possible should also be made by feel, to determine if any spars or ribs are broken. The mounting of the control horns and the alignment of the movable surfaces should be examined to insure proper operation. The stabilizer adjusting mechanism should be inspected for cleanliness and correct operation. The same remarks regarding nuts cottered and turnbuckles safetyed apply for the wings. In the fuselage the condition of both front and rear cockpits should be examined. In the pilot's cockpit the functioning of the controls should be tested to determine whether all controls move freely and to their full amount of motion; and that the ailerons line up when the stick is neutral. Engine controls should be inspected to see that they function properly. Batteries should be examined for corrosion, and switches tested. The engine section should be inspected for dirt and excessive throwing of oil of the engine. Engine-bed bolts should be checked for looseness; hose connections examined for deteriorated rubber and possible leaks; all electrical connections checked for loose or broken connections; radiator mounting checked for evidence of chafing; and cylinders checked for evidence of leaks. The propeller should be examined for looseness of bolts, alignment, and condition. All drain plugs should be safetyed. The engine may now be started and fuel pressure, oil pressure, temperature, and operation of generator noted.

METHODS OF INSPECTION AND QUALIFICATIONS OF AIRCRAFT INSPECTOR

The entire crew chief's inspection, with the exception of warming up the engine, should not take over twenty minutes, and with an experienced man this time may be considerably reduced. In addition to the crew chief's daily inspection there should be a periodical inspection of the entire group of airplanes every week or ten days. This inspection should be conducted by a representative of the General Inspection Department, who should be well qualified in his work and possess a sufficiently forceful and well-balanced personality so that the crew chief will respect him and have confidence in his judgment. A former crew chief or shop man, with the necessary technical and personal qualifications, will fit into this position very well. He should be there to assist the various workmen and not merely to find fault with their work, yet must be sufficiently firm in seeing that defects are corrected. Without a spirit of cooperation there are numerous opportunities for friction between the operating and inspection departments. Another source of information on the functioning of equipment is from the pilot's reports. It is of course impossible to rely on students' reports, but experienced pilots can be of very real assistance in aircraft maintenance by reporting any defects after a flight. The personal equation comes into this matter to an astonishing degree. One pilot will report an airplane nose heavy, and the next pilot may report it in perfect balance; or a pilot may report the aileron controls too loose on one day and the next day report them satisfactory, even though no change has been made. These instances are not a reflection on the pilots, but an indication of the peculiar condition with which one is confronted in the maintenance of aircraft. By a system of inspections and checks such as outlined it is possible to keep failures of airplane structure and of engines to a minimum. In military flying a few forced landings may be excusable, as the work required entails a certain amount of risk as a matter of training; but in commercial operation the principle that *engines shall not fail or accidents occur* must prevail. Minor troubles are to be expected occasionally, but cases where an engine suddenly goes dead when installed in a transport carrying paying passengers should not occur. Needless to add, defects of the airplane structure and faulty pilotage should also be non-existent. It is possible to accomplish this ideal by intelligent inspection and maintenance.

DATA FOR DH4 OPERATION

Certain facts in connection with the operation of DH4 airplanes at the Advanced Flying School are presented here. Unfortunately the periods of time selected are not identical in all cases, so a certain amount of interpolation will be necessary in drawing conclusions.

AIRPLANE-HOURS FLOWN

During calendar year 1923	9,660
From Jan. 1 to Sept. 14, 1924	12,975
From Sept. 15, 1924 to Mar. 14, 1925	8,010
From Mar. 15 to Sept. 14, 1925	14,551

DH4 AIRPLANES IN COMMISSION

On November 3, 1923	71
On November 3, 1924	60
On July 30, 1925	97
On November 3, 1925	104

OVERHAUL, REPAIR, AND SALVAGE WORK PERFORMED FROM JUNE 1, 1923, TO JULY 30, 1925, WITH THE UNIT TIME NECESSARY

Item	Number	Unit time in man-hours
Liberty engines, complete overhaul	209	175
Liberty engines, top overhaul	38	50
DH4 airplanes, complete overhaul	185	200
DH4 airplanes crashed and sent to shop for overhaul, included in the above 185	11	
DH4 airplanes crashed and salvaged	41	8
DH4 airplanes salvaged through fair wear and tear	24	8
Wrecks brought in from flying field	41	6
Wrecks brought in from vicinity	28	12
Wrecks brought in from 50 miles	17	36
Wrecks brought in from 100 miles	20	72
Minor Repairs as Follows:		
Radiators repaired	370	5
Fuel tanks (main) repaired	210	15
Fuel tanks (reserve) repaired	115	2
Cylinders welded	780	1/2
Metal fuselages repaired	30	1
Propellers tipped	617	8
Undercarriages assembled	240	6
DH4 controls reworked and minor repairs	153	2 to 20
Wing panels covered and doped	170	80
Ailerons covered and doped	210	10
Elevators covered and doped	180	10
Stabilizers covered and doped	200	10
Rudders covered and doped	100	10

MAINTENANCE COST PER AIRPLANE-HOUR OF FLIGHT

Multiplying the unit time in man-hours by the corresponding number of units in each item and adding these products gives a grand total of 112,404 man-hours required to keep an average

of 80 DH4 airplanes in condition from June 1, 1923, to July 30, 1925, during which twenty-six months 36,535 airplane-hours of flying were achieved. From the standpoint of maintenance it is not the number of airplanes but the flying time or airplane-hours that is important. Usually the greater the number of airplanes for a given number of airplane-hours over a certain period, the easier the maintenance. Number of airplanes does, however, affect the capital invested, and hence from an economic point of view the return necessary on the investment. An airplane kept in a glass case would have no maintenance charges against it, but would hardly be a very useful piece of machinery. Taking the figures given above and dividing the man-hours by the airplane-hours, it is found that 3.08 man-hours of maintenance were required for each airplane-hour of flight, or rating each man-hour at 60 cents, the cost of keeping the airplanes in flying condition is $1.85 per airplane-hour of flight. This figure is merely the cost of maintaining the airplanes and does not include depreciation, servicing, piloting, fuel, oil, or overhead.

Depreciation per Airplane-Hour of Flight

A figure for depreciation may be obtained by taking the value of the airplanes and engines salvaged during the period of operation from June 1, 1923, to July 30, 1925, and dividing by the number of airplane-hours of flight performed during this period, or 36,535. The records of the school show that twenty-four DH4 airplanes were salvaged during the above period, which incidentally is approximately one-eighth of the 185 airplanes overhauled. At the same time some thirty Liberty engines were salvaged. The value of a DH4 airplane without engine is $12,000, and of a Liberty engine, $4000. It is thus possible to arrive at a figure for depreciation during the period from June 1, 1923, to July 30, 1925.

24 DH4 airplanes at $12,000	$288,000
30 Liberty engines at $4,000	120,000
Total	$408,000

(36,535 flying hours during the above period)

$$\text{Depreciation per airplane-hour} = \frac{408{,}000}{36{,}535} = \$11.18$$

Looking at the matter from another angle, we may consider the time between overhaul of a DH4 airplane as 200 hours and of a Liberty engine as 150 hours, or, as previously explained, approximately two engine overhauls to each airplane overhaul. Let us now estimate the cost of maintenance and depreciation for a 200-hour period of operation on a basis of 60 cents per man-hour.

Estimates of Maintenance and Depreciation Costs on a Basis of 200 Hours' Operation

Maintenance Costs per 200 Airplane-Hours

One complete DH4 overhaul	200 man-hours	$120.00
Two complete Liberty-engine overhauls	350 man-hours	210.00
Spare parts for DH4 at 10 per cent		12.00
Spare parts for Liberty at 5 per cent		10.50
Minor repairs to DH4 airplane	10 man-hours	6.00
Minor repairs to Liberty engine	10 man-hours	6.00
Salvage of wrecked airplanes	25 man-hours	15.00
Reserve against pulling engine before 150 hours' use: 7 man-hours or 2 per cent of 350		4.20
Total		$383.70

Maintenance cost per airplane-hour = $383.70 ÷ 200 = $1.92

It should be noted that all the above items deal with labor except the third and fourth, which deal with material. This fact, however, should not preclude their being considered a maintenance expense in distinction to depreciation. In considering depreciation the field's experience has shown that a DH4 airplane can undergo eight complete overhauls before becoming so worn out that it is more economical to salvage than to repair it. A Liberty engine can stand twelve complete overhauls before being ready for salvage.

Depreciation per 200 Airplane-Hours

DH4 airplane, 1/8 of $12,000	$1500.00
Liberty engine, 1/12 of $4000 times 2, or	666.67
Total	$2166.67

Depreciation per airplane hour = $2166.67 ÷ 200 = $10.83

An estimate for depreciation can then be made on a basis of a 200-hour period of operation.

Influence of Maintenance and Depreciation on Modern Design

Efforts on the part of airplane and engine designers to reduce maintenance and depreciation charges have been directed toward accomplishing the three following objects:

1. Increasing the operating time possible between overhaul of both airplane and engine
2. Increasing the number of overhauls possible before the airplane or engine is completely worn out
3. Reducing the costs of minor repairs by provision for adequate inspection and ready disassembly and assembly.

The first two objects are accomplished on an airplane mainly by the use of simple structures and the substitution of metal in place of wood. Welded steel fuselages, when properly designed, have been very successful in operation. Steel wings, however, while satisfactory from a maintenance standpoint, have not been developed to the point where they can give as good a strength-weight ratio as similar wings of wood and wire. The use of duralumin, when properly handled, shows great promise of reducing costs. The author has particularly in mind an old Junkers airplane which had stood out in all sorts of weather, and yet after six years, was flown occasionally. It was finally salvaged because a large number of rivets had become loose or were missing. At one time veneer was used in airplane construction with the intention of providing greater rigidity. This it did, but in general its use has now been abandoned, as the veneer stood the weather very poorly and soon began to buckle and crack. Increasing the operating time between overhauls and the number of permissible overhauls on airplane engines is a matter of detailed design in reducing vibration and preventing wear of parts as much as possible. The third object, or the reduction of minor repair charges, is a matter of neatness of design which permits of ready inspection of all vital parts, and of easily removable and replaceable cowling. A great deal of time in minor repair work is consumed in removing the part from the airplane and replacing it. For instance, a radiator which requires the propeller to be pulled before it can be removed from the airplane makes a much longer repair job than an underslung type or one mounted entirely above the crankshaft. Similarly, a fuel tank which requires the airplane to be almost entirely dismantled before removal is a large repair job, even though the work actually performed on the tank requires but a few moments. An endless number of instances such as the above could be cited. It is unfortunate that the majority of aircraft designers, even though their theoretical training may be excellent, have not had sufficient practical experience in the operation of aircraft to appreciate fully the necessity of making an airplane easy to maintain.

Estimates of Total Cost per Airplane-Hour

It may be interesting to take the figures for maintenance and depreciation charges already presented as a basis, and estimate the total cost of operating a group of airplanes as a commercial venture. In addition to the above charges it will be necessary to consider fuel, oil, servicing, piloting, and overhead. Fuel and oil may be figured on the basis of the consumption of a Liberty engine at cruising speed, and servicing on the basis of 0.5 man-hour per airplane-hour. Formerly it was the policy in the Air Service for three men to care for one airplane, but now due to better shop facilities, better-trained personnel, and in part to necessity, on account of reduced personnel, three men take care of six, or sometimes even eight, airplanes. Piloting is considered at $3 per air-

Maintenance of airplane and engine per airplane-hour	$1.92
Depreciation of airplane and engine per airplane-hour	11.18
Fuel, 20 gal. per hour at 23 cents per gal.	4.60
Oil, 8 qt. per hour at 22 cents per qt.	1.76
Servicing, 0.5 man-hour per airplane-hour at 60 cents	0.30
Piloting, 1 man-hour per airplane-hour at $3 per man-hour	3.00
Total cost per airplane-hour excluding overhead	$22.76
Overhead, 100 per cent	22.76
Total cost per airplane-hour	$45.52

plane-hour and overhead at 100 per cent. In each case the larger figure for maintenance and depreciation is used.

No great degree of accuracy is claimed for the above estimates, but they are presented to invite discussion. The maintenance and depreciation given are undoubtedly too high for a commercial project. With modern equipment, in the hands of experienced pilots instead of students, this figure should be cut nearly in half. Fuel, oil, and servicing are approximately correct. Piloting is admittedly low for military flying. It must be remembered that training students, diving at targets, dropping bombs, and formation flying are far more fatiguing than cross-country flying. A military pilot will do well to put in 400 hours a year in the air, but in flying cross-country over known territory there is no reason why an experienced pilot should not maintain an average of 5 hours a day without undue fatigue. In the above estimates no figures are given for taxes, interest on investment, or reserve for unforeseen contingencies. Taxes depend upon the value of buildings, fields, and equipment; required interest return depends upon the amount of capital invested; while reserve is a matter of judgment, influenced by special considerations. It is estimated that the large figure of 100 per cent for overhead is sufficient to cover these items.

COST PER PASSENGER-MILE

If we consider on a basis of the estimates given above that the total cost of a commercial-airplane project is within $50 per airplane-hour flown, and that the average speed is 100 m.p.h., which it should be with modern equipment, we arrive at a figure of 50 cents per airplane-mile. As each airplane should carry at least ten passengers per trip, the cost of transporting these passengers would be 5 cents per passenger-mile. Any one of the items mentioned in the preceding summary of costs may be divided into an infinite number of sub-items and discussed endlessly, in the hope of arriving at a more definite figure. On the maintenance of the Liberty engine alone a textbook might well be written. Without going into further details, however, it may be stated that no commercial-airplane project, intelligently operated on a large scale with experienced pilots, good mechanics, and modern equipment, should cost more than 5 cents per passenger-mile to operate, and in time this figure should be reduced to 3¾ cents per passenger-mile.

CONCLUSION

In conclusion the author wishes to state that in his opinion the accurate analysis of costs is of fundamental importance in the planning of airplane projects.

Discussion of Papers at the Aeronautics Session

AT THE Aeronautics Session of the Annual Meeting of the A.S.M.E. on December 3, 1925, Grover C. Loening[2] presiding, the following papers were presented: The Airship and Its Place in Commerce, by H. H. Blee;[3] Maintenance and Depreciation of Airplanes and Engines, by Ernest W. Dichman;[4] and Technical Progress at McCook Field, by E. E. Aldrin.[5] The first two papers were presented by W. Laurence LePage.[6] Mr. Blee's paper appeared in the Mid-November, 1925, issue of MECHANICAL ENGINEERING, and Lieutenant Aldrin's paper with the discussion thereon in the April issue.

DISCUSSION OF PAPER ON THE AIRSHIP AND ITS PLACE IN COMMERCE

Archibald Black[7] asked whether the prewar operations of the Delag Company had been subsidized in any way. Discussing the practical limit of airplane operation, he thought that for non-stop flights, the commercial limit was between 200 and 300 miles.

W. Laurence LePage thought that at the present stage of experience it was very difficult to determine such a limit.

H. Emerson[8] stated that reliance on helium in airship operation was a mistake, its net lifting power being only half that of hydrogen, while its cost was ten times as great. Also with a hydrogen-filled airship, the hydrogen itself could be burned and the range of flight considerably increased thereby. The danger of fire, Mr. Emerson said, was not so much in the gas of the cells as in the gasoline engine, and safety lay in using a heavy-fuel engine rather than in employing a non-inflammable gas. He thought that small airships under 200 ft. in length were more promising from the point of view of commercial success than the larger ones. Airships whose maximum diameter was 30 to 40 per cent of their length were aerodynamically more efficient than those of a greater fineness ratio.

E. E. Aldrin thought that in discussing the lifting power of hydrogen and helium, only 80 to 90 per cent purity should be allowed.

DISCUSSION OF PAPER ON MAINTENANCE AND DEPRECIATION OF AIRPLANES AND ENGINES

Chairman Loening regretted that the author had not taken up the question of accident loss on planes. While Lieutenant Dichman had put the overhead at 100 per cent in his paper, Mr. Loening pointed out that the standard overhead allowed by the U. S. Government in airplane operations was 180 per cent.

Archibald Black[7] pointed out that the author's figures applied to military conditions and to student instruction. This should be carefully considered before any attempt was made to apply them to commercial operation. For the rebuilding of airplanes the author had allowed for one rebuilding every 200 hours. The labor-hours, according to the estimates obtained by Mr. Black by checking up Air Mail experience, worked out at 500 labor-hours. The material cost, incidentally, was estimated at $506 for the same type of machine. Lieutenant Dichman had given a total figure of 1600 hours of operation for the life of the airplane. Mr. Black's method of figuring the life was based on a depreciation rate of 25 per cent per annum, on the theory that the airplane was practically a new plane each time it left the reconstruction shop, and this figure of 25 per cent checked with Lieutenant Dichman's very closely. Mr. Black thought that the author's figure of 1800 hours for engine life was unheard of in commercial operation. In the Air Mail service the life of an engine ran possibly to 500 hours. The salvaging would run to about twenty-five per cent. If the cylinders were reground in operation, the life of the engine might be extended to 800 hours. Mr. Black estimated that the complete overhaul of a Liberty engine ran to 182 man-hours without allowing for supervision. The period between overhauls he had found from experience varied from 100 to 150 hours. The total maintenance cost per schedule mile flown, for an airplane with a 600-hp. engine and an 1800-lb. pay load (i.e., about 80 per cent larger as far as carrying capacity was concerned, and 50 per cent larger as regarded horsepower than Lieutenant Dichman's figures) ran as follows:

Maintenance payroll	$0.066
Engine-worn-out charge (figured on a new, modern-type engine costing $10,000, with an 800-hr. life)	0.123
If the Liberty was substituted and the value figured at $3000 and the life at 400 hr., the engine-worn-out charge became	0.075

The losses in accidents plus the repair shop's charge for normal repairs Mr. Black estimated at $0.234 per mile flown. Miscellaneous supplies, not including gasoline and oil but all others, came to $0.074 per mile flown. The planes included in this estimate were planes which cost $15,000 each, plus an engine at $10,000, plus equipment at $2500, making a total of $27,500 per plane. Mr. Black's total figure on operation, which was supposed to be all inclusive, worked out at about 50 cents per airplane-mile. This figure was accounted for partly by the charges which entered into commercial operation, but not into governmental operation of any kind. Labor was estimated at $1 per hour.

E. E. Aldrin[5] thought that it would be wise also to take into consideration the exact types of airplanes and engines on which these costs were based. With modern airplanes the repair costs would be less than with earlier types because of their greater accessibility.

S. A. Moss[9] asked whether or not the air-cooled engine was going to be more or less durable than the water-cooled.

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[2] Loening Aeronautical Engineering Corporation, New York, N. Y.
[3] Lieutenant-Colonel, Air Service. Mem. A.S.M.E., Santa Ana, Cal.
[4] 1st Lieutenant, Air Service, Kelly Field, Tex.
[5] 1st Lieutenant, Air Service, Dayton, O. Mem. A.S.M.E.
[6] *Aviation*, New York, N. Y.
[7] Garden City, N. Y. Mem. A.S.M.E.
[8] Pres., Harrington, Emerson, Inc., N. Y. C. Mem. A.S.M.E.
[9] General Electric Co., West Lynn, Mass. Mem. A.S.M.E.

Chairman Loening[2] thought that the air-cooled engine would entail less trouble and maintenance cost, and was the only practical and sensible type of engine to use.

Mr. Black pointed out that the main advantage of the air-cooled engine in maintenance was that it could be overhauled without being taken out of the airplane.

The author, in closing, said that in regard to the accident loss of airplanes he felt this should be taken care of by a reserve for unforeseen contingencies. In a well-operated organization accidents simply should not occur any more than on a first-class railroad. The loss in equipment was small in comparison with the loss of prestige and confidence which an airplane accident entailed. He believed that by selecting expert pilots and good mechanics and paying them commensurate with their ability, accidents involving the loss of life to a pay passenger would be extremely rare. It was ture that in military flying and training students certain accidents were inevitable due to the nature of the work involved in which unusual hazards must be taken. He agreed with Mr. Loening that the air-cooled engine would eventually be used, but at the present time he knew of no air-cooled engine which would give the reliability of the water-cooled Liberty. If he were selecting an engine for a particularly difficult mission and utmost reliability was essential, he would consider the water-cooled Liberty far ahead of any other engine he could think of.

Airplane-Engine Manufacture

OF LATE YEARS airplane construction has advanced very rapidly, and in both efficiency and performance modern machines have reached an exceptionally high level. To improve the efficiency of airplanes it has been necessary to devote considerable attention to the development of the engines. These are generally of the four-cycle internal-combustion type and have reached a stage of development which represents the highest expression of the art of the mechanical engineer.

Generally speaking, airplane engines may be grouped into two classes. In one class there is the special type of engine that was developed in the early stages of the aircraft movement in the belief that for air work something unusual was really necessary. These engines are not numerous now, as they are generally much too complicated to produce on a practical manufacturing basis.

In the other group of airplane engines, simplicity, accessibility, and ease of manufacture are important characteristics, accompanying which is the constant improvement that has been effected in the reduction of the ratio of weight to power. In airplane construction weight reduction is of considerable importance, provided always that reliability is not endangered. A reduction in weight of the engine enables lighter and smaller aircraft to be produced at a lower cost of manufacture, and with a correspondingly improved air performance.

Some of the most popular engines now in use have a weight-to-power ratio of 1.8 lb. per b.hp., calculated on the normal rated capacity of the engines. It is impossible to state to what degree these figures will be further improved, but at the present moment engines with a weight-to-power ratio of 1.5 lb. per b.hp. are foreshadowed.

One of the most important of the various problems with which airplane-engine manufacturers have been faced has been the difficulty of maintaining uniformity in materials. Fortunately, however, the application of metallurgical science has effected considerable improvement, and there is not the same difficulty today in obtaining materials that are uniform in quality and in all respects fully equal to the demands of the engine designer. The latter fully appreciates the necessity of an engine in which the parts can be produced without having to resort to highly skilled machining and fitting operations. Where these are introduced it would be impossible, in the event of a national emergency or any other condition that demands large-scale production, to insure that uniformity in performance and reliability which is essential.

The actual production of airplane engines is the subject with which this article is mainly concerned. A high degree of accuracy is imperative, and this can be obtained only by machine methods in conjunction with efficient tooling equipment. In many engines the design of parts necessitates an excessive amount of hand work. This calls for highly specialized workmen, and although such engines are capable of an exceptionally good performance, they can be produced only on a very limited scale. In addition to this the cost of the engines is unduly high.

By machine methods, provided they are properly applied, the desired degree of accuracy can be achieved by average workmen and uniformity in results obtained while a high rate of production is still maintained.

On the subject of accuracy it is impracticable to offer any precise statement. The tolerances on airplane-engine work are generally about half those of high-grade motor-car work. At the same time it must be added that it is not usually possible to take advantage of tolerances. Most airplane-engine parts have a weight factor, balance of parts being of great importance. For this reason the parts must be as near as possible to exact dimensions. It is quite practicable in the case of, say, a cylinder bore, to observe a tolerance of ± 0.002 in., the same as in motor-car work, but there are other parts, which are in a distinct majority, where to take advantage of a 0.0005-in. tolerance would be fatal, and any display of latitude would ultimately lead to rejection of the parts. The master ring of a static radial-type airplane engine presents a case in point. In the engine about to be considered this is a two-piece forging which is machined all over and must be to within a weight limit of 4 drams. The total finished weight of the master ring is 7 lb. 11 oz. The master ring when finished has hundreds of square inches of machined surfaces, and if the smallest tolerance were observed on but a few of these, the 4 drams weight limit would quickly be absorbed.

The airplane-engine practice dealt with in this article is descriptive of the methods employed by Armstrong Siddeley Motors, Ltd., Coventry.

The engine under consideration is of the static radial type in which a number of radially disposed cylinders are arranged around a revolving crankshaft. The chief advantage of the static radial engine is that it can be built in relatively high powers. Engines of 400 hp. are in regular production, and in the construction of engines of twice this power there are no serious production difficulties. The engines can be run continuously at piston speeds exceedingly 2000 ft. per min. and at mean effective brake pressures of more than 120 lb. at normal speed. The weight per brake horsepower of the engines is usually less than 2 lb.

A practical limit to the size and speed of static radial engines is set by the loading of the big-end bearing which is embodied in the master ring. Attempts to use ball or roller bearings on the crankpins are attended with great difficulties, and destruction of the bearings is not uncommon under the higher combined centrifugal and shock loadings.

Plain big-end bearings enable the dimensions and weight of the master ring to be kept within reasonable limits, with a consequent increase in crankshaft speed, but the design of a split big-end bearing to take the load of a number of articulated connecting rods is a difficult matter; in fact big-end bearings are often referred to as the *bete noire* of the airplane-engine manufacturer.

An additional advantage of this type of engine is the ease with which it can be mounted in the airplane. Unlike the rotary engine, which is carried by its crankshaft through the medium of ball and roller bearings, the static radial engine is mounted by its crankcase directly upon the end of the fuselage. This makes even a simpler mounting than is required for the line-type engine, and replacement of the engine is very easily effected. Furthermore, the crankshaft of the static radial engine can be made short and stiff and torsional vibrations can be effectively damped, while it is possible to effect good balance by the attachment of weights to the crank webs. (*Machinery* (London), vol. 27, no. 703, Mar. 18, 1926, pp. 793–806.)

Mechanical and Material Research in Management

"Study the Job and Not the Man"—A Method for Locating Hidden Wastes in Textile Manufacturing That Has Shown Marked Results, and Its Application in a Mercerizing Problem

By THAYER P. GATES,[1] PROVIDENCE, R. I.

IT IS THE PURPOSE of this paper to present and explain a method for locating hidden wastes in textile manufacturing which has been somewhat overlooked, but which, wherever applied, has shown marked results.

It pertains to the full utilization of the value of chemicals or materials and the transfer of this utilization to mechanical or machine power wherever possible; to the substitution of mechanical or machine power for man power in such a manner that higher wages are paid with a resultant less cost; and to equipment so developed as to utilize the full value of chemicals (or materials); eliminate handling of the product as far as possible, and simplify the job of the operator.

It is intended to show where and how the engineer trained in the fundamentals for proper application of such research becomes of extreme importance in the development of an industry.

Comparison of Present Methods with Method Described

Present methods, as the author understands them, pay labor high wages for an honest day's work and keep the equipment and labor running to capacity by proper scheduling of the work. It is his opinion that these methods for increasing production through increasing the capacity of the man by time study, bonus or piece work, or various other methods are undoubtedly excellent, but let the matter be looked at from another point of view.

If it is necessary to go to such detailed work of setting proper bonuses, piece rates, etc., why is it not as profitable—if not more so—to first apply the same effort to the equipment, materials, or chemicals used, with the idea of—

a Getting all there is from such chemicals or materials
b Relocating or redesigning this equipment to utilize in full these chemicals and materials, and of
c Substituting mechanical or machine power for labor power and eliminating excess handling of the merchandise?

In other words,

a Study the job and not the man by locating facts
b Develop the facts and transfer them to mechanical or machine power, and
c Pay the man good wages for doing a good job—teach him—make him interested in his work.

The application of this method is based on the theory that a fact once determined is usually readily applied to a practical, satisfactory solution. Therefore it is necessary in the application of this method to approach the problem in a strictly unbiased and unprejudiced manner, for it pertains to—

a The location of facts
b The development of these facts, and
c The transfer of these facts to mechanical or machine power.

A research for the elimination of extra handling of a product, or the increase of speed of equipment, or the betterment of quality usually resolves itself into a mechanical problem, or into a combination of a mechanical and a chemical problem. In the case of a chemical problem where equipment is required, it becomes (*a*) the function of the chemist to solve the full value of the chemicals and adapt them in terms for mechanical application, and (*b*) to develop the machinery to carry out the facts as found by the chemist.

Fundamentals

In order to more fully comprehend the possible benefits from such a research, the following few facts should be considered:

Each small percentage increase in the speed of any process (all else being equal) will reduce the cost of running the process, provided the total percentage capacity is increased and not decreased by doing so.

Any increase of speed, or production, due to quicker action of the same or similar chemicals used in a process will also reduce the cost.

Any loss of chemicals used in a process due to the lack of full chemical knowledge can become a source of waste, with a resultant increase in costs.

The elimination of extra handling of a product is sure to reduce costs.

Method

The method then resolves itself into the following general procedure:

1 Determine what result is desired
2 Determine the fundamental which measures the result that is desired
3 Divide the problem into
  a Chemical analysis
  b Mechanical analysis
4 Determine the fundamental of each which should be used as a standard unit to bring about the desired result
5 Determine each and every variable
  a Chemically
  b Mechanically
6 Locate the value of each variable and its relation to the others in the problem
7 If a combination of a chemical and a mechanical problem is to be dealt with,
  a Acquire full chemical knowledge of the problem or process
  b With this chemical knowledge (or facts) determined for a desired result, see that such facts are put into the proper terms for mechanical application
  c It then becomes the problem of the engineer to develop the equipment to utilize in full the facts located by the chemist.

The function of the chemist is to develop his part of the research in the following order:

1 Determine each and every variable in the chemical (or chemicals) which has any bearing on the result desired
2 Study and solve each variable, one at a time, in the chemical laboratory for the purpose of determining the best results of each as applied to the process in question and in the order of their importance
3 After the analysis of each and every variable has been made, and a full knowledge obtained as to the bearing of each to the final result desired, analyze further, to find if there is any other chemical or chemicals known that will give the same or better result at a cheaper total cost
4 Ascertain whether the desired materials or chemicals can be purchased at a cheaper price in the quantity desired
5 Tabulate the facts found in such a way that they can be understood by the engineer, and work with him in the mechanical development.

The chemist having completed the foregoing work, it then becomes the duty of the engineer to develop the equipment to conform to the facts located by the chemist in the following order:

6 Perfect a mechanical method which will develop in full the findings of the chemist

[1] Textile Specialist and Consulting Engineer. Mem. A.S.M.E.
Contributed by the Management Division for presentation at the Providence Meeting of the A.S.M.E., Providence, R. I., May 3 to 6, 1926.

7 Develop this mechanical method to handle them at a speed that is safely within the time limits of the chemical reaction
8 Further perfect the mechanical method into as continuous a process as possible, maintaining the speed called for in (7)
9 Perfect (7) so that it can be handled with a minimum of labor—but labor must not be eliminated at the expense of quality or production.

EXAMPLE SHOWING HOW METHOD WAS APPLIED

As an illustration, particulars will be given of a practical application of this method which has been termed "high-speed mercerization," and which is a combined chemical and mechanical problem.

The problem was to mercerize cotton piece goods and get the best quality (highest luster with minimum damages) at the least

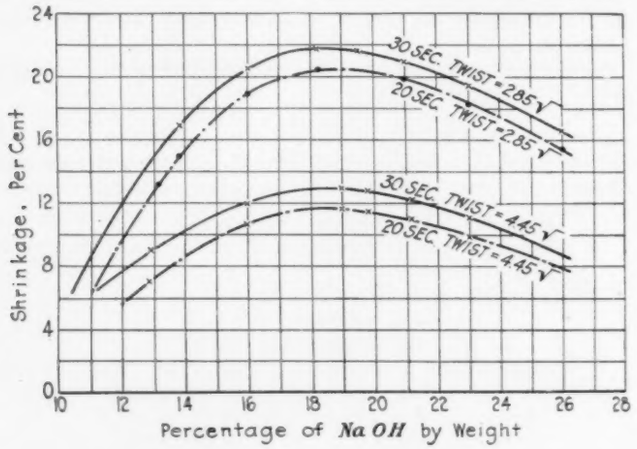

FIG. 1 EFFECT OF STRENGTH OF CAUSTIC IN MERCERIZING
(Temperature of caustic, 30 deg. cent.; Na_2O as carbonates, 3.1 per cent.)

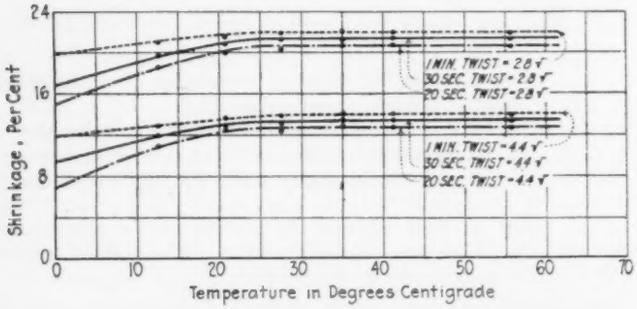
Shrinkage, Per Cent
Temperature in Degrees Centigrade
1 MIN. TWIST = 2.8 √
30 SEC. TWIST = 2.8 √
20 SEC. TWIST = 2.8 √
1 MIN. TWIST = 4.4 √
30 SEC. TWIST = 4.4 √
20 SEC. TWIST = 4.4 √

FIG. 2 EFFECT OF TEMPERATURE OF CAUSTIC IN MERCERIZING
(Temperature of caustic, 23 deg. cent.; Na_2O as carbonates, 7.03 per cent; NaOH by weight, 19.4 per cent.)

cost for labor and chemicals, and at the minimum initial expense with the equipment installed. To develop the result desired it was necessary to divide the problem as follows:

a Chemically—develop the highest luster possible on the cloth
b Mechanically—design the equipment to meet the chemical requirements for
  1 A continuous run at
  2 Maximum speed with
  3 Minimum labor.

In the early days of the mercerization of piece goods it was believed that it was necessary to have the caustic as cold as possible. Also that it was necessary to have the goods stand in the caustic from several minutes to one and one-half hours in order to give it time to act on the cotton; and that 53 to 55 Twaddell was the proper strength of caustic to use.

In the solution of this problem several types of cloth were taken and all tests of each were made on samples about eight inches square (called "swatches") from the same piece of goods in order to avoid as far as possible any chance of variation in weaving, or yarns from different mills, or varying types or character of cotton, as it was necessary to get comparative results with as little chance of error as possible.

A distance of 4 in. was marked off on each swatch (both warp and filling) in order to carefully measure the shrinkage after treatment. These swatches were then subjected to the liquor under varying conditions for definite times, and then quickly neutralized in order to prevent further action of the liquor, and dried without any tension.

It was found almost at once that the results with the Twaddell hydrometer varied to such an extent that it was necessary to use a more definite standard for measuring the strength of the caustic. The standard adopted was the percentage of NaOH by weight.

Many fabrics of various weights, twists, etc. were tested, all of which showed the same general shape of curves for percentage of shrinkage, time, strength, etc., and regardless of the size of yarns. These curves were very uniform when the twist was considered, therefore they are plotted from the same fabric in order to bring out more plainly the effect of twist on shrinkage, which in turn is reflected in luster.

The chemist then proceeded as follows:

1 To standardize the result desired, which in this problem was to obtain the highest possible luster
2 To locate the standard measurement which was used to determine the comparative values of each of the variables, and which measurement would determine the highest possible luster. In this case it was taken as shrinkage

NOTE: It was determined that maximum luster could not be obtained without maximum saturation of the cloth with caustic. That maximum saturation meant maximum shrinkage of the cloth. Therefore maximum shrinkage meant maximum luster, and consequently shrinkage was used as the standard for comparative values.

3 To locate each and every variable of the chemical which had any bearing on the result desired (which is to obtain the highest luster), these variables being as follows:
  1 Effect of strength of caustic
  2 Effect of temperature of caustic
  3 Effect of purity of caustic
  4 Effect of time in caustic
  5 Effect of twist in the yarn
  6 Effect of boiled or unboiled goods
  7 Effect of moisture in the fabric
  8 Effect of stretch while saturated in strong caustic.

SOLVING THE VARIABLES

1 *Effect of Strength of Caustic on Luster* (Fig. 1). Many different types of cloth were used for each of these tests, but as the curves all show the same general relation and shape, the author has plotted only the one for a pongee, which has a hard-twist warp and soft-twist filling. It will be noted from Fig. 1 that the greatest saturation is obtained at 19 per cent of NaOH by weight. The curve shows that saturation begins to fall off at a greater strength than this, and therefore any stronger caustic means a waste in chemicals and a detriment in quality due to poorer shrinkage. Therefore the standard set for strength of caustic for best results was taken at 19 per cent of NaOH by weight and the Twaddell was discarded. (It might be added that this is weaker than was generally supposed necessary at the time.)

2 *Effect of Temperature of Caustic on Luster* (Fig. 2). A standard caustic at 19.4 per cent of NaOH at 23 deg. cent. was taken, and the temperature of this liquor was regulated at different degrees of temperature for tests, no attention being paid to the varying of the strength due to the temperature variation.

It will be noted from Fig. 2 that the temperature of caustic has very little effect on luster above 25 deg. cent., but lower temperatures than this are a detriment, although it is interesting to note that the longer the cloth is in contact with the cold caustic, the greater effect the cool temperatures have on the shrinkage. Therefore the standard arrived at for temperature of caustic was that anything above 25 deg. cent. was satisfactory. Cooling was eliminated and a substantial saving in equipment and power was effected by doing away with cooling machines.

NOTE: It is interesting to recall that cooling was formerly believed to be very necessary.

3 *Effect of Purity of Caustic on Luster* (Fig. 3). Caustic of a standard strength (19.7 per cent NaOH) by weight was used, and by varying the carbonates it was found that they had a bad effect on the shrinkage; however, this was not considered serious as long as they did not exceed 8 per cent of Na_2O as carbonates.

4 *Effect of Time in Strong Caustic on Luster* (Fig. 4). A large number of different fabrics were tested, but they all showed uniform results for time. Therefore the curves of Fig. 4 were plotted from several different fabrics in order to show the relation between time and saturation.

It will be seen from Fig. 4 that 95 per cent of the saturation is complete in 30 seconds regardless of whether the twist is hard or soft, and that further saturation beyond this point is very slight and not necessary for ordinary commercial uses.

Therefore the standard set for time is 30 seconds for best practical results. This standard therefore becomes the basis for machine design in the saturating or impregnating pad of a mercerizing unit, and is the information desired by the engineer. It will be readily seen that this saturating pad can be designed to maintain any speed desired at a comparatively small cost.

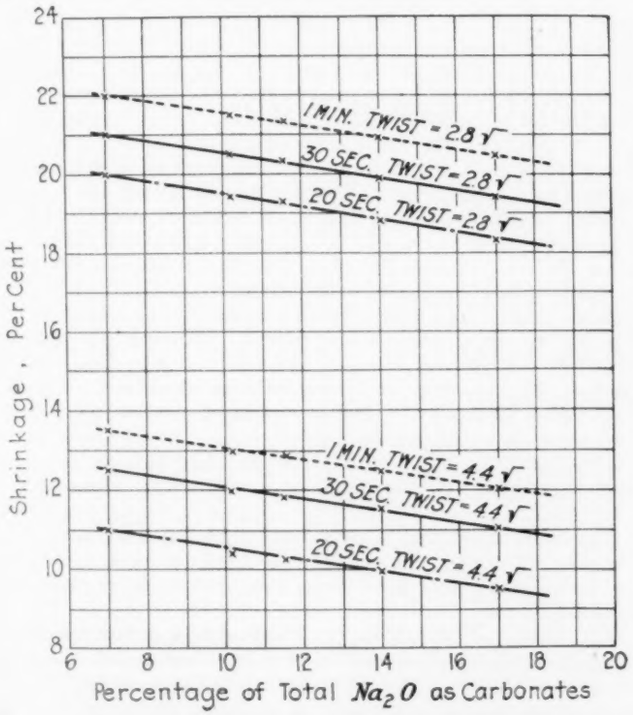
1 MIN. TWIST = 2.8 √
30 SEC. TWIST = 2.8 √
20 SEC. TWIST = 2.8 √
1 MIN. TWIST = 4.4 √
30 SEC. TWIST = 4.4 √
20 SEC. TWIST = 4.4 √
Shrinkage, Per Cent
Percentage of Total Na_2O as Carbonates

FIG. 3 EFFECT OF CARBONATES IN MERCERIZATION
(Temperature of caustic, 20 deg. cent.; NaOH by weight, 19.7 per cent.)

5 *Effect of Twist in the Yarn* (Fig. 4). It will be noted from Fig. 4 that the time for 95 per cent saturation is under 30 seconds regardless of the twist. This also proves that if the assumption that shrinkage is a measure of luster is correct, the softer the twist the better the luster should be on account of a larger percentage of shrinkage. The conclusion is *that twist has no bearing on the time for the best saturation for practical purposes, as 95 per cent saturation is gained in 30 seconds or less, whether it be hard- or soft-twist yarn.*

6–7 *Effect of Caustic Saturation of Boiled and Unboiled Fabrics with and without Moisture on Luster* (Fig. 5). The curves of Fig. 5 show that the shrinkage of unboiled fabrics (dry) in strong caustic is very poor. This is probably explained by the difficulty the caustic has in penetrating the waxes, gums, and size, which proves again that if the standard adopted for shrinkage is a measure of luster, unboiled fabrics if mercerized dry will show a poorer luster than if boiled and run dry.

It was found by running unboiled (wet) fabrics into the caustic liquor that it was difficult to maintain a uniform strength of the caustic, which gave a variation of shrinkage, and consequently a variation in luster. The shrinkage, however, was greater, due to the goods being wet, which proves that water attacks the impurities in the cotton in a manner which allows the caustic to penetrate the yarn. However, on account of the expense and difficulty of maintaining proper strength of caustic (due to the water in the cloth), it was decided to run the goods in the dry, boiled state in order to get a more uniform and better quality on the fabrics.

8 *Effect of Stretch while Saturated with Strong Caustic.* No curve is shown for this variable, but it was learned that the greater the stretch (both warp and filling) at the point where the caustic in the cloth was weakened (by water) sufficiently to relieve tension, the better the luster. This shows that the length of a mercerizing stretching frame should be determined by the speed required, as the length should be such as to gradually draw out the filling to the proper width before washing at a speed consistent with good quality and free from damage to the cloth.

The length of the stretching frame then becomes the main controlling feature which regulates the proper speed of mercerizing, for the reason that if goods are pulled to width too rapidly after

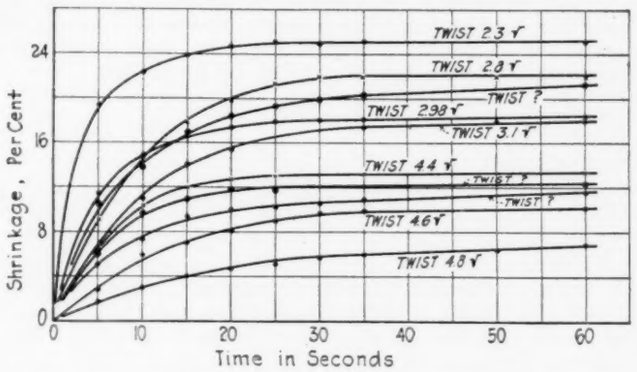

FIG. 4 EFFECT OF TWIST AND TIME IN CAUSTIC IN MERCERIZING
(Temperature of caustic, 19.8 deg. cent.; Na_2O as carbonates, 3.3 per cent; NaOH by weight, 19.6 per cent.)

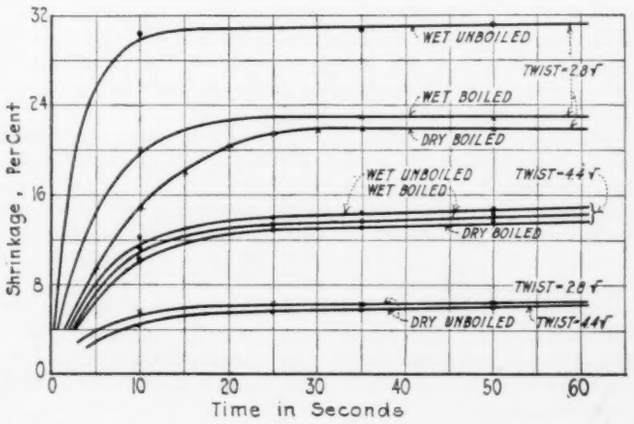

FIG. 5 EFFECT OF MOISTURE AND KIER BOIL IN MERCERIZATION
(Temperature of caustic, 20 deg. cent.; NaOH by weight, 19.9 per cent; Na_2O as carbonates, 6.2 per cent.)

shrinking in the filling in the saturating pad, damaged selvages will occur. Therefore the longer the taper on the stretching frame, the higher the speed.

SUMMARY

What was learned from this research?

1 The strength of caustic was being carried higher than was necessary for best results for either quality or production. Therefore a substantial saving in materials was made.

2 The temperature of the caustic was not of as vital a point as was supposed. Therefore a substantial saving was made in power and floor space, and less equipment was required as the cooling machine was eliminated.

3 A better standard for measuring strength of caustic was found, with the result that the caustic was utilized and reëvaporated more often, and less waste went into the sewer after the effect of carbonates in the caustic was learned.

4 The time for best saturation was found to be 30 seconds in-

stead of one to one and one-half minutes as was supposed necessary. Thus a substantial increase in production was obtained with same equipment.

5 No mechanical equipment is necessary for the solution of (1), (2), and (3). Therefore the engineer is not required.

6 The time necessary for the best saturation in the caustic having been definitely determined, the problem resolves itself into determining how fast the machine can be run, consistent with good quality in production. The problem then becomes a matter of machine design for the saturating pad as soon as the proper speed for good quality of merchandise can be determined.

7 This speed was set at 80 to 100 yards per minute for light goods instead of 15 to 25 as heretofore, which meant designing the saturating pad and frame (up to the first wash) to hold 50 yards of cloth or the amount required for 30 seconds in the caustic at a speed of 100 yards per minute.

8 After the machine was redesigned and all attachments installed that would cut down manual labor and make it as easy for the operator as possible, a method of pay was then arranged for the operator which was considered very fair for the job.

Throughout this research it will be noted that no reference has been made to the effect of different types or character of cotton used in the fabrics on shrinkage (termed the measurement for luster). This feature was not considered for the reasons that

1 It could not be controlled by the finishing plant and was therefore of no interest to them, and
2 It was difficult to get this information from the mill that had made the fabrics.

However, it seems reasonably sure that it has an important bearing on luster, and it is the author's belief that if some mill would work with a finishing plant to develop the relation of the type or character of cotton to luster by mercerization, a fabric could be developed that would show a much better luster than has been produced up to the present time.

The foregoing is an example of a hidden waste which ordinarily would not be found except through some means of research, and which, when discovered and done away with, resulted in a substantial saving in materials used, floor space, power, equipment, and labor, and in a large increase in production.

Plating Steel Auto Parts with Chromium

AFTER extensive experiment in the last two years, the General Motors Corporation has adapted chromium plating as a substitute, commercially, for nickel plating. Chromium has been known as a plating medium for some time, but the processes have been expensive. It was to overcome this disadvantage that the corporation has been experimenting at Detroit.

On March 22 the first radiator shells for public use were produced at the Olds plant, and at present production is running about 310 a day. All Oldsmobile cars now have chromium-plated radiators, and other exterior parts formerly nickeled are being plated with chromium as rapidly as factory changes can be made. These parts include lamp shells, bumpers, crankhole caps, motormeters, and hub caps. Other subsidiaries of the General Motors may use the process.

The new method is purely a plating process, there being no infusion or change of the original surface. Iron and steel objects are first given a coat of copper, and then nickeled, in accordance with the usual process. The cost heretofore of heavy nickel plating has been approximately 46 cents per sq. ft. The entire cost of chromium plating is approximately 50 cents a surface foot at present, and it is believed this cost can be reduced.

Even where it is necessary first to nickel the parts there is little difference in cost. This for the reason that the copper buff, which was required before nickel plating, is now eliminated, and the saving in labor cost practically equalizes the additional cost of the chromium plate.

The special features of the company's new process are the use of a special anode in the chromium bath and a special mixture of ingredients in the solution. Patents, in the name of the corporation, have been applied for on these special features.

The solution used is chromic acid, chromium sulphate, and boric acid. The latter two are used in small quantities, the former merely as a medium through which the chromium passes, and the latter to eliminate a film which forms on the plated commodity. Equipment being used at the Olds factory is little different from the ordinary equipment in any large nickel-plating plant. The added equipment consists merely of a tank about 3 ft. by 6 ft. in plan, equipped with an overhead vent to carry off obnoxious gases.

By the process of electrolysis, the chromium is separated from the chromic acid, passes through the chromium sulphate and is deposited on the part being plated. The rate of deposit is regulated by the amperage. A high amperage and low voltage are used, resulting in rapid deposition.

The steel radiator shells are brought to the plating department by a conveyor. After they are polished by muslin wheels, set up with glue and emery, they are dipped in an electrolytic cleaner, consisting of an alkaline solution through which an electric current is passing. A small amount of copper cyanide is used.

After the shell has been cleaned, it is copper plated. A high amperage is used in the bath of copper cyanide, and the shell is left in the bath for about 20 min. On removal the shell is washed in hot water and is ready for nickel plating.

A hot solution of nickel chloride is used, with anodes of nickel. The shell remains in this solution 40 min. Thereafter it is buffed and then cleaned in a cleaning solution similar to that used in the first instance, with the exception that no copper cyanide is used. After cleaning the shell is dipped in cold water, and is then ready for the chromium plating.

The shell is dipped by hand in the chromium bath for two minutes, completing the plating operation. It is then inspected and installed.

The chromium-plated part has a highly polished, silvery appearance. The plate is many times as hard as nickel, and extensive tests indicate that it will not tarnish or rust nearly as quickly as nickel.

The Bureau of Standards at Washington has established an accelerated corrosion test, and this test has been applied to chromium-plated parts. A concentrated salt solution is blown into an enclosed chamber, resulting in a heavy dense spray. The part to be tested is hung in this spray.

Some nickel plate begins to break down after three hours, while the best plate shows rust spots in 18 to 20 hr. It is said that parts chromium plated by the General Motors process show no material change after being subjected to the spray for 40 hr., and but few rust spots are to be seen after 80 hr. Some parts have even been left in the spray for 100 hr. without material damage.

Eighty hours of exposure to this spray is considered the equivalent of approximately 10 years of exposure to ordinary climatic conditions.

Temperature in the chromium bath is maintained at an even level by means of a dial-type thermometer, which is mounted on the tank and is visible to the operator.

The supply of chromium ore, from which the chromic acid is derived, is almost inexhaustable, according to Government reports. The domestic supply in many parts of the country is so great that it is used in road-maintenance work.

The extreme hardness of the plate is leading the corporation to continue its experiments. Experiments are being conducted with the moving parts of the motor-car engine, such as the crankshaft, valves, tappets, etc., which have been chromium plated to determine the wearing qualities of the material. (*The Iron Trade Review*, vol. 78, no. 18, May 6, 1926, pp. 1182–1183, 2 figs.)

The Economic Use of North Dakota Lignite for Steam Generation

Principal Deposits—Characteristics of North Dakota Lignite—Firing Methods—Possibility of Utilizing Lignite in the Pulverized Form—Pulverization—Cost of Steam Production

By GEORGE B. WHAREN,[1] GRAND FORKS, N. D.

THE total estimated deposits of lignite in North Dakota as reported in Bulletin No. 4 of the North Dakota Geological Survey (1925) are between 600 and 700 billion tons of 2000 lb. The figures of the United States Geological Survey, which include the vast lignite areas in North Dakota, South Dakota, and eastern Montana, are approximately 964 billion tons. The deposits in North Dakota alone aggregate a little more than one-sixth of the entire resources of the minable tons of all grades of coal in the United States.

Fig. 1 is a map[2] of North Dakota showing the general area in which the principal deposits of lignite are found. It will be noted that the lignite is located in the western half of the state and that it is widely distributed over a large area, comprising approximately 28,000 square miles.

Naturally the present electric generating stations are located in or near the larger towns which have transportation facilities, or near a lignite mine. In the more densely populated eastern half of the state are located all of the towns of 10,000 population or more. The western half, containing all of the lignite deposits, is sparsely settled, and the towns are small and widely scattered. Sufficient quantities of water for condensing steam generation of electricity on a large scale are available at or near very few lignite mines. (By large-scale generation is meant plants having 30,000 or 50,000 kw. capacity and upward.) Even if electric power could be generated at the mines, the distances over which it could be successfully transmitted in large quantities in competition with the alternative transportation of lignite are limited, especially in a sparsely settled territory. It appears that the larger plants must be located where the power markets and ample condensing water are not too widely separated. This requirement imposes severe limitations in North Dakota. At present only plants of less than 10,000 kw. capacity exist.

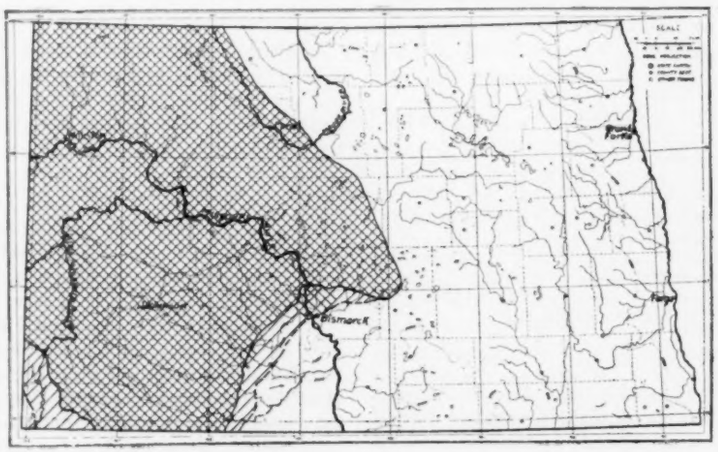

FIG. 1 MAP OF NORTH DAKOTA SHOWING THE GENERAL AREA IN WHICH THE PRINCIPAL DEPOSITS OF LIGNITE ARE FOUND

Electricity, from whatever source derived, is possibly the keynote to power and industrial development in North Dakota. Therefore efficient and economical means of generating electricity from the most promising native source of power, namely, lignite, should be of interest to engineers.

The use of lignite as fuel for steam power boilers has great possibilities and is steadily increasing. The universal use throughout the lignite district, particularly in the small heating plants, of natural draft; of the common finger-type shaking grate, and the common bar and Tupper stationary grates; of low boiler settings with the ignition arch relatively close over the grate; and in the case of horizontal-return tubular boilers, "high" bridge walls, allowing in most cases not over 6 in. as the minimum distance between the top of the wall and the boiler shell, is conducive to poor fuel economy and low boiler capacity. However, new equipment and better methods of combustion are giving far better results.

CHARACTERISTICS OF NORTH DAKOTA LIGNITE

Lignites in North Dakota are woody in structure and brownish black in color. A typical chemical analysis, as received from the mine, is as follows:

	Per cent
Fixed carbon	28.86
Volatile matter	28.46
Ash	6.72
Moisture	35.96
	100.00
Sulphur (separately determined)	0.74
Heating value	6800 B.t.u. per lb.
Fusing temperature of ash	1900 to 2400 deg. fahr.

These lignites are relatively high in moisture and low in ash content, while the combustible matters are about equally divided between the fixed carbon and volatile matter, and the sulphur content is usually very small. They are also high in oxygen, as shown by the ultimate chemical analysis. The heating value is relatively low when calculated on the wet basis; although when moisture-free, or even air-dried, the lignites have relatively good B.t.u. values.

The cost, based on fuel value, of shipping lignites containing so much moisture is high, and the moisture content also causes a reduction in the efficiency of the fuel in the furnace. Computing the heat units necessary to warm the moisture in the coal to the boiling temperature in the furnace, to evaporate and then to superheat the vapor to the temperature of the escaping gases on the basis of the typical analysis given above and assuming an initial temperature of the coal of 60 deg. fahr. and the temperature of the flue gases leaving the boiler to be 525 deg. fahr., there is required approximately 459 B.t.u. per lb. of lignite, or 6.7 per cent. This leaves only 6341 B.t.u. per lb. available for other purposes. It is therefore important that the moisture be removed before firing in the furnace. Since small pieces do not slack as badly as large lumps, it is desirable to crush or size the lignite at the mine before shipping.

FIRING METHODS

The lignites are easily handled, crush readily in a single-roll crusher, and after crushing may be conveyed and stored without any particular difficulties. The coal may be further crushed at the plant to any required smaller size as determined by the method of stoking and boiler load conditions.

North Dakota lignite on being exposed to heat does not coke but disintegrates and crumbles to a fine dust which, when burned on a grate, offers high resistance to air flow, making it difficult to obtain a uniform fuel bed and air distribution; and unless great care is exercised, a considerable amount of the "fines" may be blown

[1] Professor of Mechanical Engineering, University of North Dakota, and Consulting Power Engineer. Mem. A.S.M.E. Deceased May 1, 1926.

[2] Used by courtesy of Robert L. Sutherland, School of Mines, University of North Dakota.

through the boiler setting unconsumed. Some of the lignites have ash that clinkers badly, while others do not, especially when uniform air distribution is maintained. Slicing is prohibitive. Rocking grates afford better opportunity to work the fire than do stationary grates, and lengthen the period between cleanings but produce slightly more combustible loss in the ash.

The two chief sources of loss in burning lignite on a grate are the loss due to evaporating the moisture, and that due to the combustible matter in the ash dropping through the common types of grates, which results from the disintegration of the fuel when burning. Therefore maximum economy in the use of lignite for steam generation is to be had only by predrying or low-temperature carbonization, and pulverizing the dried lignite or carbonized residue and burning the dust in suspension without the use of grates.

At present a number of plants are using non-sifting grates, fed by a sprinkling-type stoker or coal feeder. There are also a few plants using traveling-grate non-sifting stokers. In the better of these plants efficiencies of 58 to 68 per cent by the month are prevailing respectively with the use of sized raw-lignite screenings averaging 6700 to 7000 B.t.u. per lb., 33 to 35 per cent moisture, and 5 to 8 per cent ash. It is evident that it is not possible to obtain the high efficiencies with this fuel when fired "wet" that can be obtained with low-moisture coals.

At the power plant of the University of North Dakota there is a 250-hp. Stirling boiler now equipped with Pyramid dumping grates and two Universal stokers (sprinkling type), a Bailey boiler meter set for 35 per cent excess air flow, a forced balanced-draft system, soot blowers, and an automatic feedwater regulator. From records taken daily with this boiler operating alone during the three months of November, December, January (1925–26), the following average results were obtained, using lignite 1-in. nut screenings.

1	Heating value, B.t.u. per lb.	6800
2	Moisture in coal as fired, per cent	33
3	Ash in coal, per cent	7
4	Moisture in steam, per cent	1.2
5	Steam pressure, lb. per sq. in. gage	110
6	Per cent of boiler rating developed	160
7	Feedwater temperature, deg. fahr.	200
8	Cost of fuel at plant per ton, dollars	3.17
9	Overall boiler efficiency, per cent	60.2
10	Cost of fuel for generating 1000 lb. of steam from and at 212 deg. fahr., dollars	0.37
11	Coal loss to ashpit, per cent	1.5

When this boiler was operated by hand firing, using 4-in. screenings for fuel and common finger-type shaking grates set for 40 per cent excess-air flow, an average overall boiler efficiency of about 54 per cent by the month was secured. The average fuel cost of steam per 1000 lb. from and at 212 deg. fahr. was then approximately 60 cents with practically the same grade of lignite. The cost of the improved non-sifting grate and stoker installation will be paid for by the reduced fuel bill in about one year's time.

The sprinkling-type-stoker installations may be purchased at a low initial cost in comparison with the traveling-grate and retort stokers, are cheap to operate, reliable and fairly efficient, and are meeting the financial consideration of the small plants quite satisfactorily. With hand cleaning uniform temperatures and combustion conditions are easily obtained for short periods between cleanings. The traveling-grate and retort stokers are excellently suited to North Dakota lignite so far as fuel economy, evaporative efficiency, and ability to handle this fuel are concerned.

They are also superior in handling the cheaper grades of lignite in their raw condition. But when the initial cost of this type of equipment is computed, taking into account the large grate area required for the low-grade fuel, the ignition arch together with a sufficiently large furnace volume, the auxiliary equipment, as fan, air duct, etc., the amount becomes relatively high. Few plants in North Dakota have the large capacities, good load factors, and approximately full-time operation to justify investment in this high-grade equipment.

Strict attention must be given to size of coal as well as to the thickness of the fuel bed. For hand-fired furnaces 3-in. screenings are proving to be very satisfactory when a thin fire of about 1 in. to 3 in. is maintained and a forced balanced draft is employed. With a sprinkling-type stoker the lignite works better when sized to 1 in. or less. Abundance of fine dust is undesirable, unless the fuel is predried. The traveling-grate type of stokers require a uniform size of lignite, either all of it very fine, or $^1/_8$-in. to 1-in. screenings with the dust removed.

Possibilities of Utilizing Lignite in the Pulverized Form

Lignite when dried to a 10 to 12 per cent moisture content and pulverized to approximately 40 per cent through a 200-mesh screen is an ideal fuel for burning in suspension. The high content of volatile matter with this moisture reduction and the somewhat fibrous nature of the lignite as compared to the granular shape of bituminous particles make for freeness of combustion. The increased heating value of the dried lignite also improves this coal as a fuel for steam production.

As a result of experiments by the author, sufficient progress has been made in drying, pulverizing, and burning lignite in suspension to warrant further development of this method. It has been determined that dried lignite (mine run or screenings) with a moisture content up to 15 per cent, or carbonized lignite residue, may be used with probable resulting overall boiler efficiencies of 73 to 78 per cent by the month, exclusive of superheater and economizer.

The commercial success for the small plants operating at present in the lignite territory depends on the following essential factors:

1 Low initial cost
2 Small maintenance charges
3 Reliability in service
4 Fine pulverization with a minimum of power
5 Large coal-grinding capacity with small floor space.

For the smaller plants the unit system, where the coal is burned as it is pulverized without storing, is the most economical although not as desirable as the storage system from the standpoint of dependability, taking care of sudden peak loads, etc. The maintenance and reliability of the unit system itself is primarily a matter of machine design and care in operation. The drying before pulverizing, the fineness of pulverization and the power requirements; the furnace design and the proportion of the entire equipment; the cost of steam production; are all important problems to be specially considered in adapting pulverized-fuel equipment to lignite use.

Waste-Heat Drier. Speaking from a combustion standpoint, it is not necessary to dry lignite. However, from a purely mechanical and economical standpoint, drying is desirable in order to maintain the full capacity of the pulverizer, to reduce the power for grinding, and to aid in producing fine pulverization.

There has been developed a stationary waste-heat drier which is flexible in design, cleanly in operation, and which uses the stack gases for drying, and the present indications are that the power required for its operation is about three kilowatts per ton of input per hour. Unless such a drier is used the power required for grinding is practically prohibitive with the raw lignite containing 30 per cent of moisture and upward, as it is usually received from the mine.

In this drier the wet lignite is charged at the top, and drops by gravity at a rate regulated by the operation of a gate at the bottom according to the capacity desired. The cross-section of the coal vein is 3 ft. by 12 ft., and the drier proper, exclusive of the coal hopper over it, is 16 ft. high. The flue gas is diverted by means of a fan from the stack and drawn through tuyeres passing horizontally and in direct contact through the coal for a travel of about 18 inches. Using 1-in. screenings and with a drying time of approximately four hours, and a fan discharge of 15,000 to 17,000 cu. ft. per min. (at 120 deg. fahr.), about 3 tons (output) of lignite may be dried per hour from 33 to 35 per cent moisture content to 10 to 12 per cent.

Pulverization. Lignite is tough in grinding and offers marked resistance to fine pulverization. The capacity of any of the several mills on the market depends largely on the moisture content. Screen-type and ball mills do not operate satisfactorily on coals of high moisture content. The various mills of the impact air-separation type seem to grind the lignite quite satisfactorily up to 15 per cent moisture content, but above this amount of moisture the capacity of the pulverizer drops off rapidly and the power required for grinding is increased considerably.

It is more difficult to secure and maintain uniform fineness of pulverization than with bituminous coals. Lignite has a great tendency to clog in the mill, and requires a large amount of air to be drawn through with the coal in order to clear the mill, which fact tends to make for coarse pulverization. Complete air separation, therefore, seems highly desirable. Hence the mills provided with an air-separating chamber through which the coal passes before it is discharged give better operating conditions in regard to air control and quality of pulverization, because the velocity of air may be increased through the grinding section of the mill. The coarse particles which are then carried along are separated in the chamber by a reduction in the velocity of the air, and return to the mill.

Lignite apparently does not need to be pulverized to as fine a degree as do the bituminous coals. Very good combustion and flame conditions are secured with about 40 per cent through a 200-mesh screen and 70 per cent through a 100-mesh.

Speaking generally, lignite should be dried to 10 or 15 per cent moisture content to maintain the capacity of the mill, which percentage is about the air-dried point for most North Dakota lignites; and the fuel thus treated may be handled and stored in dry bins without danger of increasing in moisture content.

For dependable pulverizer service somewhat oversize mills and drives should be installed for lignite as compared with bituminous-coal installations. In general, the mill, with 15 per cent moisture content in the lignite, may be calculated to have about 75 per cent of the bituminous-coal capacity and to require about 10 per cent more power for driving than that required for bituminous coals.

Cost of Steam Production. With a waste-heat drier and unit pulverized-fuel system using North Dakota lignite, the cost of steam production has every indication of being about 20 per cent less than that of producing steam with the ordinary hand-fired furnace using the improved non-sifting grates. Also, it is believed that when properly installed and operated the cost will be reduced below that of the average sprinkling-type stoker, and in the long run will at least equal that of the traveling-grate stokers in the small plants. This is probably true in the case of the sprinkling stoker because of the higher efficiency, and in the case of the traveling-grate stoker because of the lower fixed and maintenance charges.

CONCLUSION

Plant operators in the North Dakota lignite district should study the matter of burning the local fuel, because the probabilities are that it can be burned profitably, especially in plants located within a radius of about 200 miles from a lignite mine. For plants located at a greater distance, drying or some other preparation at the mine to reduce the moisture content before shipment is desirable. The requirements for the economical use of lignite in most of the existing plants may be met with a relatively small financial outlay, provided good engineering practice is followed. The availability of power following on the utilization of lignite will encourage the establishment of manufacturing industries, which may be made to work harmoniously with a well-diversified agricultural industry.

The Diesel-Electric Locomotive and Its Relation to Heavy Electrification

THE METROPOLITAN Sections of four National Engineering Societies met in a joint session on the evening of February 18, 1926, in the Engineering Societies Building, New York City, for the purpose of discussing the Diesel-electric type of locomotive and its relation to heavy electrification. The organizations represented were the American Society of Civil Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the American Society of Mining and Metallurgical Engineers. Addresses by engineers of recognized authority in their several fields dealt with the various angles of the problem, and considerable additional information of value was brought out in the discussion which followed. Extended extracts from the reports of the three addresses are given below. George J. Ray, President of the New York Section of the American Society of Civil Engineers, presided throughout the session.

The Diesel-Electric Locomotive and Its Various Applications

BY HARTE COOKE,[1] AUBURN, N. Y.

THE motive power best suited for any particular railway service is dependent entirely upon local conditions. The best way to get an idea of the effect of Diesel-electric locomotives on the electrification of steam railways is to look into the characteristics of the different types of motive power and the requirements of some of the special kinds of railway service, in order to determine the type of motive power best suited for the service.

MOTIVE-POWER CHARACTERISTICS

Steam Locomotives. As a standard of comparison the steam locomotive may be taken; its characteristics are as follows: Tractive-effort curve of maximum value, limited by the weight on the driving wheels; total weight on driving wheels limited by the loads permissible for a given track structure, also the number of wheels possible to use; maximum tractive effort maintained practically constant up to ten miles per hour, falling off approximately inversely as the speed thereafter, and approaching a hyperbola limited by the horsepower which can be developed by the cylinders and the boiler capacity of the locomotive. With this form of curve a locomotive can pull at considerable speed any load which it can start, the full horsepower being developed at high speeds only.

As a matter of reference, the weight of the steam locomotive with the tender may be taken as 100, and the cost likewise. The horsepower output is limited by the size of boiler accommodated by the usual railway clearances, it being possible to arrange a sufficient number of axles to keep the axle loading within permissible limits. A tender must be supplied to carry fuel and water. The fuel cost may also be taken as 100. Provision must be made to replenish the water and coal supplies; the ash pan must be dumped and the ashes taken care of at frequent intervals; the boiler must be cleaned at certain longer intervals, and the entire locomotive repaired from time to time, all limiting the time in service. One effect of getting maximum output with a minimum of weight is to reduce the time available for road service. The actual service time may be taken as 100.

Diesel-Electric Locomotives. The Diesel-electric locomotive is able to develop its full horsepower at any speed, which, with the even torque of the electric motor, gives a high tractive effort at starting, the weight being such that practically all of this can be utilized.

The tractive effort is generally inversely as the speed, the curve being approximately a hyperbola equivalent to the net horsepower, giving the locomotive the ability to easily start any load it can draw at a reasonable speed, and to accelerate rapidly. The Diesel weighing about 50 per cent more per horsepower than the steam locomotive, the weight may be taken as 150. The cost being about three or four times that of the steam engine, may be placed at 300 or 400. The maximum output can be arranged as desired, since multiple-unit control is possible.

It being possible to carry the fuel and water on the locomotive and eliminate the tender, and allowing for there being no stand-by

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losses, the fuel cost may be taken as 30 as compared with steam.

Regarding care, only a small amount of fuel and water are required at infrequent intervals; no boiler cleaning is required; and usual traffic conditions will allow the limited repairs required by both Diesel and electrical equipment. The time in service will be represented by 200, or twice that of the steam locomotive.

Electric Locomotives. The tractive effort of an electric locomotive, the curve of which approaches a straight line, is limited by the weight on the driving wheels, falling off as the speed increases; but the usual changes in connections of the motors as the speed increases bring the tractive effort from time to time near the original value. This form of tractive-effort curve not only gives high accelerations at starting, but also high speeds with heavy trains, the motors being able to use a large amount of actual power at high speeds.

The weight bears a certain relation to the tractive effort desired, and if the arrangement is such that all the weight is on the driving wheels, the electric locomotive will weigh less per horsepower than a steam locomotive. The weight may be represented by 75.

The locomotive itself might cost about the same or considerably more than the steam locomotive, depending on the arrangement. In any case, however, this cost has to be considered in connection with the cost of the power house and transmission system, and, in general, may be represented by 300 to 600.

Considering the losses in the transmission system and the known results from central stations, the relative fuel cost may be taken as 37.

These locomotives can be arranged for multiple-unit control, so that any output desired can be obtained. All equipment necessary for operation is on the locomotive, no tender being required.

Regarding care required, the locomotive does not have to stop for water or fuel, and the care required amounts to the usual periodic inspection and maintenance of running gear and electrical equipment, all of which can be done during idle periods due to traffic conditions, enabling the locomotive to be in service over twice as much time as the steam locomotive. This time may be represented by the figure 225.

Tabulated, the approximate relative values appear as follows:

	Locomotive		
	Steam	Diesel-electric	Electric
Weight per hp	100	150	75
Cost per hp	100	300 to 400	300 to 600
Fuel cost per hp	100	30	37
Time in useful service	100	200	225
Maintenance	100	75	50

Requirements of Some Classes of Railway Service

Subways. The conditions to be met in this case are very heavy traffic, a great number of stops, strict maintenance of schedule, and maximum acceleration at starting with minimum discomfort to passengers, requiring tremendous power capacity for a train with the minimum weights carried. Further, there must be no objectionable gases in the stations, the maximum power requirements are for but short periods of acceleration, and a large number of trains per mile of road results in a large power requirement per mile. These conditions eliminate the steam locomotive at once.

The Diesel-electric locomotive is suitable so far as the tractive-effort curve for high acceleration is concerned, but the weight added to the train would increase the power necessary to give the desired acceleration. The maximum power being required for but short intervals, the average power would be low, with a high investment based on the maximum demand. The gases would be objectionable. The fuel cost would be moderate.

For full electrification the tractive-effort curve is the best that could be had for maximum accelerations. With motors on the passenger cars the weights would be at a minimum, resulting in maximum acceleration with a minimum of power. There would be no gas and a minimum of heat would be liberated. The maximum of power being required for acceleration only, the effect of the diversification factor results in a minimum power-station cost, and the high traffic density per mile of road will reduce the relative cost of transmission lines and third rail. Power generation in an efficient power house will result in low fuel cost. Balancing the operating results against the capital investment necessary gives the following figures:

Using a Diesel-electric locomotive, the weight of the train would increase 30 per cent, requiring 30 per cent more power to give a certain desired acceleration, the relative cost of the locomotive then being $1.30 \times 300 = 390$. With motors on the trucks the weight of the train would be increased about 10 per cent, the relative cost then being $1.10 \times 300 = 330$. The diversification factor might reduce the size and cost of the power house one-third, which would reduce the capital cost for electrification by about one-half of this amount or one-sixth, showing finally five-sixths of 330, or 275, and indicating a lower capital cost for electrification. The fuel costs would be $1.3 \times 30 = 39$ for Diesel power and $1.1 \times 37 = 40.7$ for electrification, indicating a saving too small to justify the increased capital cost of the Diesel-electric installation.

Heavy Suburban Service. This service closely parallels that of the subway, with the exception that the traffic is not so heavy. Assuming that the traffic is about 50 per cent of that in the subway and the distances between stations greater, the relative costs would be as follows:

The steam locomotive would add 20 per cent to the train weight, so for a given acceleration the capital cost would be 120 and the fuel cost 120. Due to the nature of the tractive-effort curve, the Diesel-electric locomotive would show a reduction of 10 per cent in horsepower, the cost then being $0.90 \times 1.30 \times 300 = 350$. The fuel cost would be $1.3 \times 30 = 39$. Third-rail and transmission lines coupled with the use of a locomotive instead of motors on the trucks would show for the electrified line a first cost of $1.2 \times 400 = 480$. The diversification factor, on account of the lighter traffic, would amount to about 20 per cent, and the power house would be a smaller part of the total investment, reducing the capital cost by about 7 per cent and resulting in the figures $0.93 \times 480 = 455$. The fuel cost for the electrification would be $1.2 \times 37 = 44.4$.

The first costs and relative fuel costs would work out as follows:

	Steam	Diesel-electric	Electric
Cost	120	350	455
Relative fuel cost	120	39	44.4
Taking the use factor the above would be modified as follows:			
Cost	120	175	202
Relative fuel cost	120	39	44.4

Assuming an annual fuel cost for the steam locomotive of half its first cost, then the fuel bill for the Diesel-electric locomotive would be $(39 \times 0.5)/120 = 16$ per cent of the first cost.

The annual saving of 34 per cent of the locomotive first cost would more than justify the extra capital cost shown for the Diesel-electric locomotive for the suburban traffic.

Heavy Main-Line Traffic. In this type of traffic there is some advantage of the diversification factor, although not nearly so pronounced as for the suburban and subway traffic.

There will be a heavy traffic density, also large amounts of power will be required to maintain the high speeds necessary to get the maximum capacity out of the line, especially if the grades are heavy.

For these conditions the lesser value of the diversification factor requires a much larger power house with a greater capital expenditure for electrification. The heavy traffic density, however, reduces the cost and losses in the transmission line. Accelerations do not figure to any great extent, it being more a matter of horsepower.

The steam locomotive would add about 20 per cent to the weight of the train, so the capital cost would be 120 and fuel cost 120.

For the Diesel-electric locomotive the form of tractive-effort curve would not help. On level track the 30 per cent added weight does not deduct 30 per cent from the performance, so the capital cost will be $1.3 \times 400 = 520$, and fuel costs $1.3 \times 30 = 39$.

For full electrification the electric locomotive would add 20 per cent to the train weight, making the capital cost $1.2 \times 400 = 480$, and the fuel cost $1.2 \times 37 = 44.4$. The diversification factor would be small, about 10 per cent, which might reduce the capital costs by 5 per cent, making it $0.95 \times 480 = 455$.

A tabulation of these figures follows:

	Steam	Diesel-electric	Electric
Capital cost	120	520	455
Relative fuel cost	120	39	44.4

On account of the greater useful time with the Diesel-electric and electric, the above figures change as follows:

Capital cost	120	260	203
Relative fuel cost	120	39	44.4

From these figures it can be seen that full electrification would justify the increased capital costs.

Light Main-Line Traffic. In this case trains are infrequent, traffic density light, and high-speed schedules may not be required. On account of light traffic, no benefit is obtained from the diversification factor. A relatively large amount of transmission-line and overhead or third-rail work is required. The following figures apply to this service:

Steam operation: capital cost, 120; fuel cost 120
Diesel-electric operation: capital cost, 520; fuel cost, 39.

Full electrification, on account of the long distances, would be $1.2 \times 500 = 600$ for capital cost, and $1.2 \times 37 = 44.4$ for fuel cost.

The figures are tabulated below.

	Steam	Diesel-electric	Electric
Capital cost	120	520	600
Fuel cost	120	39	44.4
On account of the use factor these would be as follows:			
Capital cost	120	260	267
Fuel cost	120	39	44.4

The above saving in fuel would justify Diesel-electric operation. However, in some special cases with heavy grades to increase the capacity of a single-track line to save the cost of double track, complete electrification would give the large amounts of power available for each train, so that faster schedules on grades would result and the capacity of the line would thereby improve. Also, in this case, regenerative braking is advantageous. These might justify complete electrification.

Long Branch-Line Service. Such lines usually have relatively light traffic, do not require fast schedules, and would not justify the expense of electrification. Passenger traffic could probably best be handled by Diesel-electric rail cars and the freight by steam locomotives.

Short Branch-Line Service. Here traffic would ordinarily be light and no fast schedules required, and therefore such lines would be unsuited for complete electrification. Special cases of heavy suburban traffic and connection with electrified main lines might justify electrification. However, for light passenger traffic the gasoline rail car is to be preferred, the Diesel-electric car for heavier traffic, and steam locomotives for freight haulage.

Switching. Electrification is not suitable for switching service owing to the small power requirement, low power factor, and expensive third-rail and overhead-work installation and maintenance.

Figures for steam would show a capital cost of 120 and a fuel cost of 120. Switching speeds being low, advantage could be taken of the Diesel-electric locomotive tractive-effort curve, permitting the use of 50 per cent of the steam-locomotive horsepower. The following figures would result: Capital cost, $0.50 \times 1.3 \times 300 = 195$; fuel cost, $1.3 \times 30 = 39$. Full electrification would reduce the horsepower 50 per cent, but the overhead work would be greater, bringing the figures up to $0.50 \times 1.2 \times 600 = 360$ for capital cost and $1.2 \times 37 = 44.4$ for fuel. These figures with the use factor, less than usual, included, are tabulated below.

	Steam	Diesel-electric	Electric
Capital cost	120	130	210
Fuel cost	120	39	44.4

The fuel saving, although small, coupled with the absence of smoke and noise and the elimination of ashes, coaling and taking on water, would more than justify the increased investment of the Diesel-electric installation.

CONCLUSION

Summing up, light freight and through passenger traffic can best be handled by the steam locomotive, with gasoline rail cars for local passenger service. Conditions should be carefully analyzed to determine the proper time for supplementing steam locomotives by Diesel-electrics. Full electrification should be used for heavy traffic, since it has been shown that it gives dependable service at a low fuel cost. The Diesel-electric locomotive is not suitable for subway service, owing to the gases, to traffic conditions requiring great numbers of stops, and to the extra power required for accelerating the extra heavy equipment. Steam is also out of question here because of the gases, leaving full electrification as the only solution.

The Diesel-Electric Locomotive, Its Field and Advantages

BY N. W. STORER,[2] EAST PITTSBURGH, PA.

MR. STORER spoke of the tremendous interest of the railroads in a form of locomotive that would eliminate many of the disadvantages of the steam locomotive, while retaining its advantages. In the Diesel-electric locomotive he saw the elimination of much of the smoke, dirt, and noise, and the frequent roundhouse repairs. In addition, it had four times the thermal efficiency of the steam locomotive with the flexibility of the electric.

As a solution of the problem of transmitting the energy of the engine to the wheels of the locomotive, he mentioned the European attempt to combine the direct mechanical method with the hydraulic. The mechanical method was not satisfactory, since the locomotive was not self-starting and did not operate satisfactorily at low speeds. The hydraulic method, he felt, would develop troubles and lose efficiency with age. The electric method was most satisfactory, being flexible and maintaining its full efficiency throughout its life.

The Diesel-electric locomotive, he said, was very similar in its characteristics, performance, and equipment to the motor-generator type of alternating-current locomotive, which took its power from a single-phase trolley and utilized it in a synchronous motor to drive a direct-current generator supplying current to the driving motors. The main difference between the two locomotives lay in the fact that the output of the Diesel engine was limited to a very definite value which could be carried for long periods, while the synchronous motor might carry very heavy overloads for short periods.

Desirable Features of Electrical Equipment. The most important features of the electrical equipment he enumerated as follows:

1 The ability to utilize the full capacity of the engine at all speeds
2 High efficiency, so as to transmit the maximum amount of energy to the wheels
3 Simplicity of control
4 Light weight.

Voltage control, while said to give maximum flexibility for control of speed and tractive effort, was operative only up to the normal voltage of the generator and over most of the range while overloading the motors and generator, he explained. Overvoltage might be secured by forcing the generator fields, and where voltage was limited a further speed control might be obtained by weakening the fields of the motors. This practice, he explained, would cause no difficulties from commutation, owing to the absence of surges and fluctuations in voltage in the unit power plant. Special care was necessary to secure the best adjustment of the commutating field for high speeds, but this, Mr. Storer explained, was purely a matter of good design.

He favored the connection of motors two in series rather than series parallel, claiming that such an arrangement was more efficient for road service where low speeds were encountered, and also on account of the greater efficiency at heavy loads because of the decreased generator current.

Mr. Storer placed great emphasis on the importance of providing electrical equipment of the highest possible efficiency. This was not only important from the standpoint of fuel consumption, but because of the greater energy available at the wheels with the more efficient electrical equipment.

A simple electrical control was urged, especially because of the

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complications of the Diesel engine and its auxiliaries. The system most commonly used, he said, was one providing an automatic control of the generator voltage, limiting its output and thereby avoiding danger of stalling the engine. The system was usually combined with the engine-speed control, keeping the speed as low as possible and thereby avoiding maintenance difficulties and the expense of excessive lubricating-oil consumption.

Some of the auxiliaries mentioned were pumps for water circulation and lubrication; air filters and radiators, with a ventilating system for cooling the engine; air compressors for brakes, preferably electrically driven; means for starting the engine (either by compressed air at 200 to 500 lb. per sq. in., or current from a storage battery, using the generator as a motor), also a small amount of control apparatus for the electrical equipment. A good supply of oil, water, and fuel must be provided.

Weight. Weights per horsepower, Mr. Storer said, ranged from 207 to 400 lb. The largest locomotive of the Diesel-electric type was one of 1000 hp., weighing 275 lb. per hp. Engines varied tremendously in weight according to the manufacturer and the type adopted. An engine of 340 hp., weighing 16 lb. per hp., was mentioned, and it was said that its use in a rail car on a Canadian railway had demonstrated that there was a possibility of Diesel engines of larger capacity being built to operate successfully with as light weights per horsepower. The engine weight, he explained, was but a small part of the total weight of the locomotive, the weights of the various auxiliaries pyramiding very rapidly, so the figure of 200 lb. per hp. would require refinements and ingenuity to attain. He considered 200 to 300 lb. a safe figure.

The Field of the Diesel-Electric. This type of locomotive, Mr. Storer felt, would have a very definite field in transportation circles. The first, he considered, would be branch-line service. Switching was another field mentioned, the absence of dirt and noise and low maintenance charges being in its favor. The absence of complicated overhead wiring was mentioned as another advantage for this service. For main-line service the Diesel-electric locomotive would be suitable for slow-speed freight. It was like the steam locomotive in one respect, he pointed out, that being its limitation to the amount of power generated within itself.

Electrification, Mr. Storer said, would go forward in terminals and on railways having heavy traffic where the investment in overhead lines and substations did not represent a considerable part of the cost of electrification.

He felt that the Diesel-electric and the straight electric locomotives would move side by side in the improvement of rail transportation. He saw many years of service ahead for the steam locomotive, but explained that its increasing complications would eventually force extensive retirement in favor of one or the other of the electrics.

Advantages of the Oil-Electric Locomotive Over Electrification on Short-Line and Switching Operations

BY C. H. STEIN,[1] NEW YORK, N. Y.

THE first steam locomotive to be operated in this country the *Stourbridge Lion*, imported from England by the Delaware & Hudson Company, weighed but 8 tons as compared with the latest locomotive of that company, which weighs 273 tons. The tractive power of the former, Mr. Stein said, was but 2000 lb., while that of the latter was 104,000 lb. The efficiency of the latest design was 52 times that of the 8-ton engine. Prior to 1900 there were but few improvements in the steam locomotive, the greatest development occurring during the following 20 years.

The multiplicity of parts likely to get out of adjustment, Mr. Stein felt, was one of the great problems in the steam locomotive, since much valuable time was lost through shop repairs. Owing to the fact that additional improvements meant additional apparatus to be repaired, he felt that the steam locomotive could not be expected to show further great improvement. He contrasted the slow improvement in the applications of steam with those of electricity, mentioning the steps from the first cable street cars to the electric cars and buses in general use. He was unable to account for the fact that the railroads of the country had been slow to electrify their lines in the face of these great improvements in electrical transportation.

Many considered the new Diesel-electric locomotive to be an infant prodigy, from which no one knew just what to expect, but which every one seemed to feel would eventually show worthwhile results. The early forms of gasoline engines had been looked upon in much the same way, but the forced development of the World War period had produced engines suitable for a multitude of purposes.

The question had often been asked when the Jersey Central lines would be electrified. Mr. Stein's personal feelings were that they never would be, his hopes for over ten years having been that a satisfactory form of self-contained electric or gas-electric car would be developed which would make the great expense of electrification unnecessary. He had never felt that the economy of electrification was sufficient to overcome its high first cost. This fact probably accounted for the slowness with which electrification was proceeding. Another obstacle was the high cost of motive power. The third rail or overhead wires were not desirable from the standpoint of safety, and tie-ups often resulted from sleet and ice on the rails and wires. Further, trouble in the power house affected the entire operation.

A further objection was the necessity for supplying means for meeting the peak power demands encountered only on special occasions, the remainder of the year requiring but a part of that peak demand.

Many short lines interchanged traffic with other lines, a practice likely to result in difficulties under electrification, owing to the fact that it was not an easy matter to induce different companies to view the situation from the same standpoint. This condition, Mr. Stein said, had caused great difficulty in the matter of automatic train control, and the problem of electrification would be harder to solve.

Mr. Stein saw an element of danger in industrial districts, in that it would be necessary to install extensive electrical equipment to permit operation within factory yards, and many places existed where it would not be possible to work out an economical solution.

The first oil-electric locomotive to be operated in the vicinity of New York City for switching service was the product of the General Electric, American Locomotive, and Ingersoll-Rand companies, and had been operated in the Bronx terminal of the C.R.R. of N. J., since the latter part of last year, where it had been thoroughly tested under severe conditions.

Some of the advantages of such a locomotive were as follows: It was a self-contained unit; the power was generated and applied within this single unit; disturbances on the line would not affect the ability to produce power; a heavy investment was not required to meet peak power requirements, it being only a question of the number of units and their sizes. A further advantage lay in the fact that changes from steam power could be made gradually, new locomotives of the new type being added as the power demands were made or as old equipment was scrapped. Experiences in snow storms and blizzards indicated that less trouble was to be expected from the oil-electric locomotive than from other forms of power.

There were reasons for believing that the oil-electric locomotive had a greater thermal efficiency at the rim of the driving wheel than any other form of power used for handling railroad traffic; and Mr. Stein was also of the opinion that the high-grade mechanic required for electrification installations would not be needed for the operation and maintenance of such locomotives.

The reasons leading to the adoption of the oil-electric locomotive for the Bronx terminal had resulted from a very thorough investigation in which the advantages of various forms of electrification has been considered and their relative costs, etc. weighed. In this particular case it has been found that the advantages of the oil-electric locomotive for switching purposes indicated that it would give the best service for the conditions at hand. Mr. Stein wished it understood, however, that he was not advertising the oil-electric locomotive, as he was of the opinion that an influx

[1] General Manager, Central Railroad of New Jersey.

of ideas might be expected from Sweden on the Diesel type of locomotive; also he could not predict the outcome of the work at the Baldwin Locomotive Works on this type of engine.

Statistics covering cost of operation were in general not accurate: too often in making calculations of depreciation the statistician neglected to figure the depreciation of the old steam locomotives into the total.

In regard to fuel consumption, it might be said that the oil-electric locomotives used in the Bronx terminal operated at about one-fifth the fuel cost of the steam locomotive, figuring on the best grades of anthracite.

General Discussion

EDWIN B. KATTE,[4] who opened the general discussion, said he felt that the Diesel-electric locomotive would act as a stimulus to electrification, for, with its use to any considerable extent, the cost of electric locomotives would be likely to drop.

He mentioned switching as the most promising field for this type of locomotive, or service between yards operated under different systems of electrification. Another field mentioned was branch-line service with light traffic. It must operate with a minimum of noise, however, and with no smoke, and the economy in operation must at least equal that of the electric locomotive and the first cost be less than the combined cost of the electric locomotive and the working conductors.

The ultimate cost of the unit, Mr. Katte said, was a grave question. He felt that the price should be greatly reduced, and explained that it was with the hope that mass production would produce the desired result that trial orders had thus far been awarded. Also, he said, the economic advantage must be definitely established. He mentioned two orders placed for locomotives weighing over 100 tons each. A passenger locomotive weighing 148 tons was to be equipped with a Diesel engine of 800 hp. It was designed for main-line light passenger service. A freight locomotive weighing 128 tons was to be equipped with a 750-hp. engine. The passenger locomotive was designed for a maximum speed of 60 miles per hour and the freight locomotive for 40 miles per hour. The usual speed of the passenger type would be between 15 and 50 miles per hour, and between 8 and 35 for the freight.

W. B. Potter[5] felt that the electrical form of power transmission for the Diesel locomotive was the most desirable form available. The ease with which the engine could be replaced by an overhead wire seemed to him to be in favor of electrification as traffic conditions changed.

The many places in which the motor car and Diesel-electric locomotive would be found advantageous would, in most cases, be found to be those places which, at least under the present state of development, would not be found at all favorable for electrification. In so far as the use and operation of such equipment tended to extend the use of electric motive power, it was going to be beneficial toward electrification.

It would be perfectly obvious that the engine on the car or locomotive could be replaced by an overhead wire and supplied from a power station without involving anything very new; and familiarity with that type of equipment would certainly have an effect favorable to electrification rather than otherwise.

For such service the Diesel-electric locomotive had the advantage in that it could be equipped with duplicate motive power, and in that way maintain a better road factor than would be possible if a single engine of twice the size were used.

The possible return on the investment was considered the determining factor in the selection of types of locomotives for the various services encountered. The conditions under which the engine was forced to operate made it necessary to carefully study the design with respect to weight and reliability of service.

Mr. Potter also touched upon the desirability of the Diesel locomotive from the standpoint of maintenance, fuel economy, and thermal efficiency, agreeing with the other speakers on this point.

Sidney Withington[6] referred to the years of development back of the steam and electric locomotives, and mentioned thel ack of data upon which to base maintenance figures for the Diesel-electric type of locomotive. The first cost, he felt, would be reduced considerably as production increased.

Commenting on full electrification, he said that its reliability had been demonstrated to be far greater than that of steam.

He felt that standardization would help greatly to clear up much of the confusion surrounding electrification systems. Personal safety was largely a matter of education, and would improve as experience was gained. The cost of electric and Diesel-electric locomotive power would also drop as time passed, he believed. He referred to the railroad strike of 1922 as an example of the ease with which service could be maintained with electric locomotives, the labor required for maintenance being of a less skilled nature than that required for steam locomotives. He felt that the same could be said to exist, to a certain extent, in the case of the Diesel-electric.

Mr. Withington, as did the other speakers, referred to the importance of carefully considering the problem before deciding upon the type of locomotive. He agreed that it would be impossible to use the Diesel-electric type in subway service and for heavy traffic, the extremely heavy trains in some cases requiring more power than could possibly be generated in one unit. In dense traffic the cost of the locomotive would be excessive.

As an indication of the diversity factor obtained by electric operation, he mentioned a road on which the aggregate horsepower represented by the locomotives was more than four times the capacity of the power plant.

If the motive power in this case were changed to Diesel-electric locomotives, he pointed out, the aggregate cost would be practically twice that of the entire electrical system, including power plant, transmission and distribution system, and electric locomotives. In addition there would probably have to be greater terminal facilities for refueling the Diesel locomotive, and additional engine houses to effect repairs on account of the added complications. Transmission-system maintenance costs would amount to a very small figure, comparatively, in extensive electrical systems.

Another point raised was the possibility that the great demands for oil as a fuel would change the economic status decidedly. In this case the central station, which could be made to burn any type of fuel, might show the greatest advantage, Mr. Withington said.

Another point of application of the Diesel locomotive, not mentioned by the other speakers, was for work trains, particularly wrecking trains, where the constant losses for steam equipment were a large proportion of the total fuel consumption. The electric locomotive would not be suitable for such service, because of the necessity of operating with a dead rail at times. The deciding factor in selecting the type of motive power was the probable density of traffic per mile of track.

J. G. Dudley[7] referred briefly to the results possible through careful attention to the steam locomotive. He mentioned a plant built by Hiram Maxim, which was of 360 hp. capacity and weighed but 6 lb. per hp.

The work of the late Dr. Diesel was referred to by H. H. Suplee,[8] who said that in 1912 a Diesel-electric locomotive had been built in Switzerland by Sulzer Brothers, but the development stopped because of Dr. Diesel's death and the World War.

W. S. Murray[9] said that the answer to economical transportation lay in the annual charge for that transportation, which was divided between the fixed charges made up of interest, insurance, depreciation, and taxes upon the new property created to perform that operation, and the annual operating expense.

He, too, felt that the field of the Diesel-electric locomotive would be in yards, on branch lines, and possibly on light traffic on main lines, but never on heavy main-line traffic.

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[8] New York City. Mem. A.S.M.E.

[9] Consulting Engineer, Murray & Flood, N. Y. City.

Gas as a Factor in the Production of Oil

By K. C. SCLATER,[1] PONCA CITY, OKLA.

"GAS AS A FACTOR in the efficiency of oil production" might be a better title for this paper, as it deals in general with the significance of the gas-oil ratio as an index of the efficiency of oil production, and briefly discusses oil-production methods with reference to the gas-oil ratio in wells, particularly during the early life of a field.

In the recent hearings held at Washington before the Federal Oil Conservation Board, the fuller utilization of the energy contained in the gas occluded in or associated with the oil underground was stressed by some of the speakers when referring to greater ultimate recovery of oil.

One speaker, commenting on this point, said in part: "There is ample evidence indicating that if the gas associated with the petroleum in our fields were conserved and elevated gas pressure maintained in the oil sands during their productive life, the ultimate production of oil could be greatly increased." This fact, the author thinks, will be generally admitted.

Instead of the "gas-oil ratio" of oil production, let the term "gas factor" be employed, as it is just as applicable and is a more convenient term to use for purposes of discussion. The gas factor is defined as the number of cubic feet of free gas produced with a barrel of oil. A reduction of the gas factor over a whole field, or sometimes in one well, has some significance. If the minimum volume of gas, consistent with economy, is produced with each barrel of oil, or, to put it in another way, if the expulsive energy of the gas is efficiently utilized, the life of the field as a whole is conserved and a greater ultimate recovery of oil will result. From an operating viewpoint the flowing life of the well is lengthened, with a resulting decrease in lifting cost of the oil.

The possibility of maintaining the original gas pressure in a field by returning the gas already produced after treating or supplying gas under pressure to the sands from an extraneous source, is evident, but it is not the author's purpose to discuss this phase of the problem but rather to dwell on the more immediate aspect of the problem, that is, of greater utilization of the energy of the gas associated with the oil in the sand, particularly in the early life or "flush" production period of a field.

In this connection the following statement from an authority who has given much thought to the problem, is quoted:

> While the operator cannot control the original conditions of energy and resistance in the sand, he can partly control the efficiency of expulsion. As it is the energy contained in the compressed and absorbed gas rather than the oil that is exhausted, it is but logical to judge the efficiency of a producing method largely by the relative quantities of gas produced with each barrel of oil. If by a change in method the producer lessens the proportion of gas with each barrel of oil, he should increase the total recovery of oil correspondingly, even if the rate of production is temporarily reduced somewhat.

This statement was made, not recently, but about nine years ago.

The attention which has been given to this aspect of the problem, relative to the economical production of oil by operators and trained engineers alike, is notably scant, especially when the profitable results attainable are considered. This apparent apathy is perhaps accounted for by the inherent conditions that have existed in many oil fields in the past, wherein the operators of adjoining properties producing from the same sands are concerned chiefly in obtaining maximum oil production in a minimum of time, regardless of the volume of gas produced with the oil.

Since the ultimate volume of oil which can be profitably recovered from any area is contingent on the character of the natural expulsive forces underground, the character of these forces should be an influencing factor in the choice and development of suitable production methods. Inasmuch as the dominant natural expulsive forces of the most important oil fields in the Mid-Continent area are due to gas pressure, it follows, from this reasoning, that the most efficient methods to adopt are those in which the smallest volume of gas, consistent with economy, is produced with each barrel of oil.

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Presented at a joint meeting of the Mid-Continent Sections of the A.S.M.E. and A.I.M.E., Tulsa, Okla., March 5, 1926.

With these facts in mind, then, it is obvious that one essential is to investigate, as soon as put on production the producing characteristics of the first wells drilled in a field. Experience indicates that field experimental work on wells usually is productive of beneficial results, and well justifies any extra expense involved in such work.

Before experimental work is started all available information regarding the well should be gathered and given close study. This information should include the drilling history, thickness and arrangement of productive sands, rock pressures, casing, perforations, and liquid levels. Every field, and, indeed, more often every well, has producing characteristics peculiar to itself. Any beneficial results that might be obtained by the adoption of a new method in one field would not always be indicative of results in another field. It is for this reason that every effort should be made to gather information and investigate methods which will assist in overcoming production difficulties and reduce the gas factor in the average well.

There are so many variable factors and unforeseen conditions influencing the production of oil from a well that we cannot afford to overlook any reliable index for comparing the efficiency of production methods in use. In the gas factor we have such a reliable index.

As to the magnitude of the gas factor under present methods of producing oil, this is largely dependent on local conditions, such as the relative volumes of gas and oil present; whether the gas is free or occluded in the oil; the disposition of the oil sands; the depth of the well, the size of the casing or tubing, and, perhaps, to some extent, the gravity and temperature of the oil. The gas factor may be anywhere from 400 cu. ft. or less in old pumping wells to 6000 cu. ft. or more in flowing wells. A fair average gas factor is probably about 1800 to 2000 cu. ft. In some fields, during the period of flush production, the average may run as high as 4000 to 6000 cu. ft.; in other fields it may be only 600 to 800 cu. ft. Nor does it appear from tests that the gas factor of a well or field remains constant under present methods of production. As the sands become depleted of oil, more energy is required to move the oil to the well. There is also a greater tendency for bypassing of the gas in the sand, hence the gas factor may increase with the age of the flowing life of the well.

A flowing well in operation is somewhat analogous to the air lift used in raising water. The principle is the same except that natural gas is the levitating medium instead of air. In the case of a flowing well, however, the problem of raising the oil is more involved and not so positive of solution as that of raising water. The stage has not yet been reached where our knowledge of underground and well conditions will enable us to enumerate and evaluate the various factors involved and allow of the problem being solved entirely with pencil and paper; hence recourse must be had to experimentation in the field to determine the production methods best adapted to local field conditions.

In order to get a clearer understanding of oil-well flow, let us assume, for example, an ideal case of a well with oil and gas in sufficient quantity to maintain a steady but vigorous flow through the casing without any restriction of flow being placed on the well. As the gas pressure diminishes, a point will be reached where the volume of gas will not be sufficient to maintain a steady flow. At this point the well then starts flowing by heads. As the pressure and volume of gas diminish still further, the interval between heads will increase and the intensity of flow decrease until the well fails to flow at all. When this period in the life of the well is reached, a pump is installed and the well's flowing life is presumably ended. Now, if during the life of this well, accurate measurements of the quantities of oil and gas produced were made, it would probably be found that the period of greatest efficiency of production in the flowing life—that is, the period when gas factor was lowest—would be that in which the well flowed by heads.

When a well flows by heads the nature of the flow is somewhat similar to the flow induced by stopcocking a well. Stopcocking tests made on wells indicate that the gas factor is lower than when the wells are induced to flow continuously. Difficulties of auto-

matically stopcocking wells have not yet been satisfactorily solved to meet all conditions, hence this method of controlling well flow is still in the development stage.

In the first period, that of steady but vigorous flow, there is an excess volume of gas under high pressure present, sufficient in amount to energize the column of oil in the casing and cause the well to flow vigorously with a large amount of slippage or bypassing of the gas through the oil, thereby resulting in a high gas factor.

In the second period, that of flow by heads, when the pressure and volume of the gas have diminished and are insufficient to energize the column of oil in the casing continuously, there is a slow surging or heading of the fluid column in the well, and bypassing of the gas through the oil is reduced, thereby resulting in a low gas factor.

If, instead of allowing the well to flow unrestrictedly through the casing, we applied back pressure on the well by some means and found that by controlling the back pressure we could reduce the gas factor appreciably without affecting the oil production, we might feel justified in applying back pressure to oil wells, even though our gas production was reduced, because of the greater ultimate oil recovery and longer flowing life of the well that would result.

Field tests have shown that reduction of the gas factor can be accomplished by controlling back pressure in a well.

It is not the author's purpose to advocate any special method of applying back pressure on wells, but instead to stimulate thought among operators and field men directly responsible for oil production, in the hope that more experimental field work of this kind on wells will be undertaken.

The method of applying back pressure will depend almost entirely on well conditions. Flowing a well through tubing packed off at the casinghead with a bean or flow nipple connected in the tubing permits of better control of back pressure than when the well is allowed to flow through the casing. However, it is often not possible or advjsable to install tubing in a well because of the hazard present, especially in high-rock-pressure areas.

Results obtained in field tests made about five years ago on producing wells with the object of reducing the gas factor were so encouraging that the author feels this phase of the problem of oil production warrants closer attention and study by all operators than it has been given in the past.

If wells in a field having a gas factor of 4000 cu. ft. can be made to produce the same amount of oil with a gas factor of 2000 cu. ft., the flowing life of the well will be doubled and the ultimate recovery of oil increased. That this is possible of accomplishment is sufficient incentive to make the average operator and production man have as much interest in the number of cubic feet of gas produced with each barrel of oil as in the amount of production of oil itself.

For the most efficient operation of wells it is necessary to take into account the gas production as well as the oil production.

Other disturbing conditions may enter which will influence the method of operating a well. Here might be mentioned paraffin trouble. The deposition of waxy residues, known throughout the oil fields as "paraffin," is often a prolific source of trouble and expense in well operation. Examination of samples shows that it consists chiefly of amorphous wax, precipitated salts, fine silt, and gummy residues, any one or a combination of which constituents may predominate. The relative amount present depends largely on the character of the oil produced, the properties of the water—if present—produced with the oil, and the character of the productive sands in the well.

From observations made on tubed flowing wells the paraffin deposit is found to extend to widely varying depths in the tubing in different wells, and may be anywhere from a few hundred feet or less to 1000 ft. or more.

From the lowest point upward the deposit gradually increases in thickness, reaching a maximum at the top of the tubing string. The lowest point to which the paraffin extends in the tubing closely approximates the fluid level in the well. This would indicate that as the well grows older and the fluid level falls, an increase in the depth of the deposit may be looked for. The amount of paraffin deposited is dependent on the properties of the oil, the gas pressure, and the ratio of gas to oil produced. A study of what takes place in the well will explain more clearly the conditions under which the paraffin is deposited in the tubing.

When great volumes of highly compressed gas are released, or, in other words, expanded, great quantities of heat are taken up by the gas. In a well producing oil and gas under relatively high pressure, the heat absorbed by the gas in expanding is taken from the oil, thereby chilling the latter and causing paraffin to separate out and subsequently deposit in the tubing. As the expansion of the gas is gradual from the bottom of the well to the surface, the chilling effect on the oil reaches a maximum at the casinghead, resulting in the greatest precipitation of paraffin at this point. The following temperatures taken in three wells indicate to some extent the degree of cooling which oil may undergo during its upward course to the surface:

Average daily oil production	Average gas factor	Temperature at depth, deg. fahr.	Casinghead temperature, deg. fahr.
94 bbl.	1236	100 at 2334 ft.	66
79 bbl.	894	110 at 4027 ft.	66
37 bbl.	2981	98 at 3143 ft.	66

That the deposition of paraffin does not take place below the fluid is probably due to the presence of sufficient liquid, which minimizes the chilling effect of the expanding gas by dissipating it. The reduction of the gas factor therefore tends also to decrease paraffin trouble.

From a series of tests made on wells in an effort to control the volume of gas produced with a barrel of oil, the following conclusions regarding the effect of tubing a well and controlling back pressure by changing the size of flow nipple were arrived at.

In the tests the tubing was packed off at the casinghead and a flow bean or flow nipple installed in the tubing to control well pressures. Previously to the test it was the practice in this field to allow wells to produce through a flow nipple at the casinghead as long as they would produce, and then put them on the pump.

Tests on these wells showed that, in general, flowing a well through tubing increased oil production and reduced the gas factor.

In wells having a relatively low gas factor, high gas pressure, and high average oil production the beneficial effects are likely to be more marked than in wells having a high gas factor, low gas pressure, and low average oil production.

The effect on oil and gas production of changing the size of flow nipple in flowing wells is dependent on well conditions and on the volume and pressure of gas produced with the oil.

If the flow nipple is too small, there is a decrease both in average oil and average gas production, and an increase in the gas factor. If the flow nipple is too large, there is no perceptible change in average oil production, an increase in gas production, and a resultant increase in the gas factor. It should be noted that the effect on the gas factor is the same whether the flow nipple is too small or too large. That is to say, for each flowing well the proper size of flow nipple that gives maximum average oil production with minimum average gas production has a certain limited range, above or below which the gas factor is increased. The net effect on oil production is more marked in wells with a high average gas factor.

There was no conclusive evidence to show that any marked advantage was gained by placing the flow nipple at the bottom of the tube instead of the top. From an operating standpoint it has a serious disadvantage if it is desired to change the flow nipple.

It was found that in flowing wells, particularly those with tubing, the gas factor decreased as the back pressure was increased, indicating that the gas production is more affected than the oil production, the net effect on production being dependent on the volume and pressure of the gas present in the well.

A well flowing through tubing can maintain a higher average yield of oil under high back pressure than when flowing through the casing under low pressure.

The significance attached to casinghead pressure as an indicator of back pressure in a well should depend on the operating conditions, whether the well is flowing through the casing or tubing. In a well flowing through the casing the casinghead pressure is not always a reliable indicator of back pressure or well conditions, because of the irregularity and wide range of fluctuation of fluid level in the well.

Objection might be raised here to the expense involved in obtaining the gas factor for each well, as it would mean making individual well tests to ascertain the volume of gas produced with each barrel of oil. In many cases, however, it is possible to obtain the gas fac-

tor for a number of wells producing into one battery of tanks, in which case an average gas factor can be arrived at for the wells under consideration.

It is usually possible, however, to obtain the gas factor in the first well drilled, and to do some experimental work on the well to reduce the gas factor if it is found too high.

The installation of one test trap to a battery—this trap to have a sufficient capacity for one well—with an orifice meter located at the gas outlet and a liquid meter at the oil outlet, and so connected that the production from any one well can be switched into the test trap, is also suggested as a convenient method of obtaining production test data.

Graphical Methods of Calculation

A PAPER bearing the above title and presented at the 1925 Annual Meeting by Prof. Herbert L. Seward, associate professor of mechanical engineering, Sheffield Scientific School of Yale University, discussed at length the construction of Cartesian diagrams and alignment charts for use in the rapid determination of the values of unknown quantities in mathematical expressions. This paper, the discussion of which is summarized below, appeared in the Mid-November, 1925, issue of MECHANICAL ENGINEERING, page 1019.

Ed. S. Smith, Jr.,[1] contributed a written discussion in which he stated the alignment diagram was admittedly economical of drafting work as it consisted of merely positioning points upon lines of various forms, but that it was open to the serious objection that the slight deformations occurring in reproductions impaired its accuracy. On the other hand, the section-paper method of plotting values upon a background, although not as economical of effort nor as flexible as the alignment-diagram method, had several basic advantages which made it the more practical of the two. This paper could be readily purchased, drafting labor was reduced to a minimum by its use, no rules were required with the finished diagram, and photographic imperfections or shrinkage of the surface in reproduction did not appreciably affect the accuracy of the diagram as the background ruling was affected equally with the values plotted thereon. A paper of this type, known as "probability paper," was coming into increasing usefulness in the field of hydraulics and economics, and had the property, useful to engineers, of turning a frequently met curve into a straight line.

Carroll F. Merriam[2] wrote regarding the utility of the inverse scale for $y = 1/x$ in indicating the value that a dependent variable approached when the prime variable approached infinity. For example, if the coefficient of discharge as given by Hamilton Smith, were plotted for suppressed and contracted weirs and a direct scale used for the width of the weir, B, the result would be two curves converging, at first rapidly with small values of B, but becoming nearly parallel as B became larger. If, on the other hand, the inverse scale suggested in the paper were used, these two curves would appear to converge as if to join at a fairly definite value for the case where the width of the weir was infinite.

It was sometimes useful in connection with graphical calculations to slide one curve plotted on tracing cloth over another. It was possible to avoid by this the tedious process of computing backwater problems by trial and error. The origin of the coördinates, upon which the transparent curve was plotted, was placed to coincide with the point on the vertical scale of the lower curve sheet which corresponded to any given water-surface elevation at either end of the reach in question. The intersection between the curve on the transparency and the curve on the lower sheet, which was a graphical representation of the relations between the resistance of the channel to the flow of the water as a function of the height of the water in the channel, showed at once the drop in water surface through the reach.

By extending the same principle to the case of two intersecting warped surfaces, graphical solutions might also be quickly derived, even though neither of these surfaces had known equations. In fact, the problem of indirect fire employed in artillery work might be so treated, even though the surface of the earth was entirely accidental and the trajectory of the shell was mathematically very complicated. To execute the whole upon a plane instead of employing models, each of the surfaces was represented by "contour lines."

R. F. Gagg[3] wrote of the increasing interest in graphical methods of calculation, and pointed out many possible applications. The paper, clear in all other points, suffered from the greatest weakness of nomography in the lack of an adequate method for writing equations in the determinant form.

E. J. Loring,[4] wrote that it was interesting to compare Fig. 33 of the paper, for the solution of the complete cubic equation, with one for the same purpose given in D'Ocagne's Calcul Graphique et Nomographie. In Professor Seward's nomogram the curves were for the independent term, while in D'Ocagne's the curves were for the second-degree term. It also appeared possible to construct a nomogram for this equation having the curves for the first-degree term, but such a nomogram would give poor intersections. The paper gave methods applicable where formulas were known, but nomograms were often desired in cases where no formulas could be found, in order to facilitate interpolations, and in such cases the nomogram could be determined only by repeated trials. Mr. Loring asked whether Professor Seward could offer a definite procedure in such cases. It was stated that if a formula could not be written as a determinant, no diagram could be made for it. Did it follow that if a diagram could be made, a formula could be found?

C. J. Jefferson[5] discussed the question of a man without a technical training being able to use graphical methods in the operation of oil-burning vessels. A logarithmic chart where the slope of a straight line corresponded to the index of the viscosity of the fuel had proved very useful to chief engineers of such craft.

E. F. DuBrul[6] stated that he was surprised that engineers did not make greater use of logarithmic paper, which could be a great time saver in many types of calculations and required the learning of but a few simple methods.

H. L. Jenkins[7] said he did not consider it necessary to use determinants in graphical methods of calculation, as more straightforward processes could be applied. It was not always possible to deduce the equation of a curve by logarithmic methods, he said, and it might sometimes be found necessary to apply many other tests.

W. F. Turnbull[8] said that in dealing with curves, mathematicians had always advised him to put the curve in series form. If three or four terms of a series were taken and constants calculated, a sufficient degree of accuracy was always obtained.

Professor Seward in his closure stated that while discussers had apparently been more interested in obtaining the equation, given a curve, his paper had been concerned with the drawing of the curve, given the equation. He defended the use of determinants. He thought that it was possible to use logarithmic or other paper in deducing equations by very direct methods and by substitution in typical equations.

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The Making of Special Slide Rules

DETAILS of the steps to be taken in constructing arithmetical and logarithmic scales, and of their use in the construction of slide rules, as well as descriptions of slide rules for the solution of various formulas, were given by G. W. Greenwood in a paper presented at the 1925 Annual Meeting of the A.S.M.E., and published in the Mid-November, 1925, issue of MECHANICAL ENGINEERING, page 1002.

Carl G. Barth[1] in a written discussion of Mr. Greenwood's paper, said that he had been interested in the making of special slide rules since the summer of 1899 when he had constructed those superficially described in his paper on Slide Rules in the Machine Shop as a Part of the Taylor System of Management.[2] He agreed with the author that the subject was fundamentally very simple, yet in dealing with involved equations the construction of special slide rules had taxed his ingenuity greatly. Yet a logarithmic scale was of a simple nature and could be readily, and quite accurately, constructed by a simple graphical method, the understanding of which did not even necessitate a knowledge of logarithms.

Considering the geometrical progression

$$-1/16-1/8-1/4-1/2-1-2-4-8-16-$$

the terms of which were numbers equally spaced on a logarithmic scale, this might also be written in the form

$$-2^{-4}-2^{-3}-2^{-2}-2^{-1}-2^{0}-2^{1}-2^{2}-2^{3}-2^{4}-$$

in which the various exponents for 2 were then respectively the logarithm to the base 2 of the corresponding numbers in the original progression.

On a logarithmic scale these logarithms were represented by the respective distances at which their numbers were located from the graduation mark for the number 1, and for each number this distance was then that multiple of the distance between 1 and 2 which was expressed by the exponent that the number had in the second progression; or in other words, its numerical logarithm to the base 2.

The fundamental principle of any logarithmic slide rule, Mr. Barth wrote, was implied in the manner in which the multiplication of any two numbers in the first progression above was effected by raising the base 2 to an exponent which was the sum of the exponents of the two factors, as found in the second progression, when that number in this progression which contained this sum-exponent in the second progression would be the product sought. Thus

$$1/2 \times 16 = 2^{-1} \times 2^{4} = 2^{3} = 8$$

The logarithmic slide rule performed this addition of exponents of numbers, i.e., their logarithms—or inversely when division was involved—by the physical addition of the distances along its scales that represented these exponents or logarithms.

But of course a logarithmic scale incorporating only the few stray numbers forming the terms of the two progressions above would be of no practical use. However, as each term in either one of these two identical progressions was the geometrical mean of, or mean proportional between, its two neighboring terms, one might, by taking advantage of this simple fact, readily interpolate one subterm between each two of the terms in the original progression; e.g.,

$$1/16-1/16\sqrt{2}-1/8-1/8\sqrt{2}-1/4-1/4\sqrt{2}-1/2-1/2\sqrt{2}-$$

$$1-\sqrt{2}-2-2\sqrt{2}-4-4\sqrt{2}-8-8\sqrt{2}-16-$$

or

$$2^{-4}-2^{-3.5}-2^{-3}-2^{-2.5}-2^{-2}-2^{-1.5}-2^{-1}-2^{-0.5}-$$

$$2^{0}-2^{0.5}-2^{1}-2^{1.5}-2^{2}-2^{2.5}-2^{3}-2^{3.5}-2^{4}-$$

This process might be repeated as often as desired, but without leading to practical results because of the odd figures into which the interpolated terms would evaluate.

[1] Retired. Life Member A.S.M.E.

[2] Trans. A.S.M.E., vol. 25 (1904), p. 49.

Hence to effect this interpolation graphically recourse was had to falling back on a geometrical construction of a mean proportional between two lines that rested on a Euclidian theorem that read about as follows:

> A chord in a circle is the mean proportional between the diameter drawn from one of its extremities and that segment of the diameter which is intercepted by the perpendicular from the other extremity of the chord.

This graphical interpolation of numbers between 1 and 2 only was shown in Fig. 1.

The ordinate 1-*a* represented the number, 1, whose logarithm was 0, and the ordinate 2-*b*, of double the length of 1-*a*, represented the number 2 whose logarithm was 1 (itself represented by the length of the abscissa 1–2). About the middle point *c* of 2-*b* the circle 2-*db* was then drawn, making the chord 2-*d* = $\sqrt{1.2}$ =

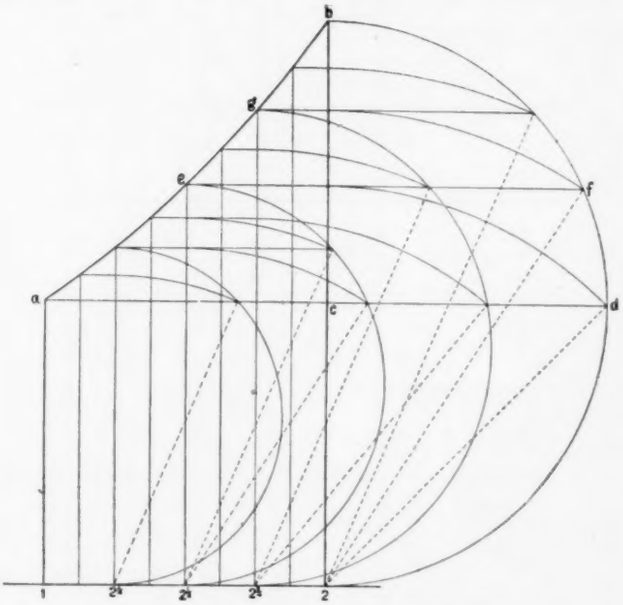

FIG. 1 CONSTRUCTION OF ANTI-LOG CURVE

$2^{1/3}$, which was then interpolated as the middle ordinate $2^{1/2}$-*e*. The chord 2-*f* = $\sqrt{2^{1/3} \times 2} = 2^{3/4}$ was next interpolated as the ordinate $2^{3/4}$-*g*; and so on, as fully indicated. Finally the curve *aeb* was drawn, and was thus a curve whose ordinates represented numbers (or anti-logarithms) of logarithms to the base 2 represented as abscissas, when the abscissa 1–2 was considered unity. This distance might, however, be considered to represent the logarithm of 2 to any base, as, for instance, 0.30103 for the base 10, or 0.69315 for the natural system of logarithms.

The use of this curve for interpolating nineteen points between 1 and 2 on a practical logarithmic scale was shown in Fig. 2, and also the manner in which, by the successive multiplication by 2–4 and 8 of the notations on this scale, this fragmentary logarithmic scale was used for the building up of a complete logarithmic scale covering numbers from 1 to 10.

But while for years the various logarithmic scales on his slide rules were reductions by the method shown in Fig. 3 of a large logarithmic scale generated as just described, Mr. Barth had some years ago abandoned this in favor of a set of three different sizes of engine-divided logarithmic scales specially made by the Kueffel & Esser Co., of New York. These were identical with those on that company's regular 10- and 20-in. Mannheim slide rules for general computations, and each scale was engraved on the two edges of an ordinary double-edge drawing scale.

Generally Mr. Barth was able to use one or more of these standard logarithmic scales directly in making some of the scales on any new rule wanted, but when not able to do this he made reductions from

the largest of these excellent logarithmic scales in the manner illustrated in Fig. 3.

C. W. Keuffel[3] said that as a manufacturer of slide rules he constantly received inquiries for special rules; but he thought that ordinarily most problems could be solved on the standard slide rule.

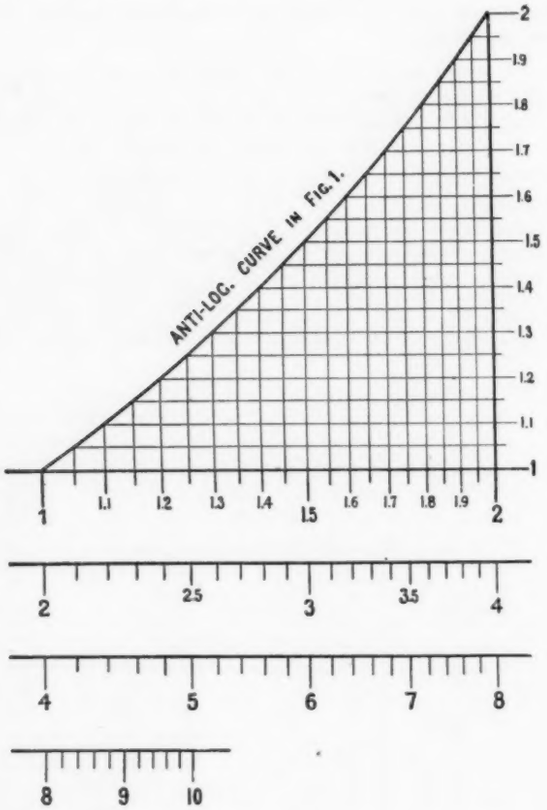

FIG. 2 CONSTRUCTION OF LOG SCALE BY MEANS OF AN ANTI-LOG SCALE

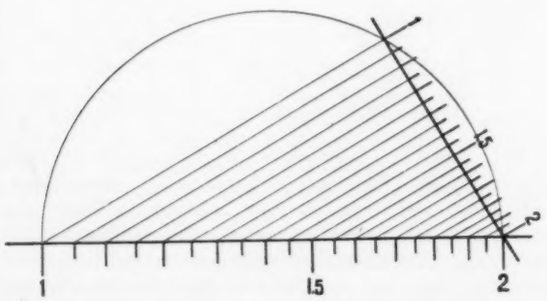

FIG. 3 REDUCTION OF A STANDARD LOG SCALE BY THE SIMILAR-TRIANGLE METHOD

E. F. DuBrul[4] described the application of special slide rules in statistical studies of a fluctuating industry such as the machine-tool industry.

C. L. Ragot[5] exhibited a scale 5000 in. long, divided logarithmically into 100,000 divisions. This scale was incorporated in a book of but 40 pages, could be read both ways, and did away with all interpolations, tables of proportions, etc.

In closing the discussion the author wrote that the paper had been written for the individual who had a recurrent problem involving the product of two or more functions, each involving a single variable, but who was not familiar with any slide rule, either standard or special; in fact, for one with a minimum of mathematical equipment. Such a person was concerned only with a special form of slide rule which would afford a ready solution for his particular problem.

For this reason every step in the paper had been made as clear as it had been possible for the author to make it. Philosophical discussion underlying the construction of slide rules had been avoided, and the scales had all been developed by simple, straightforward arithmetical computations, using only a book of log tables and a rule divided into tenths of an inch. In fact, a working model of the most complicated of the scales shown had been readily constructed by a high-school boy who had never seen a slide rule of any kind, but who had simply followed the steps as outlined in the paper.

[3] Supervisor Optical Department, Keuffel & Esser Co., Hoboken, N. J. Jun. A.S.M.E.

[4] General Manager, National Machine Tool Builders Association, Cincinnati, O. Assoc. A.S.M.E.

[5] Staten Island, N. Y.

The High-Efficiency Oil Engine

A PAPER under the above title was recently presented to the Institution of Mechanical Engineers (British) by Alan E. L. Chorlton, and was published in *The Automobile Engineer* for April, 1926 (vol. 16, no. 214, pp. 127–132). An editorial in the same issue is of interest. In this it is claimed that Mr. Chorlton's facts and figures are rather brief, and also perhaps necessarily a little incomplete. Apart from the all-important questions of economy, it says, reliable engines of this type should have the effect of placing air transport on a new plane of safety as regards fire risk.

Regarding the detail of the high-speed oil engine as a type, the editorial continues, the two outstanding problems in development are those relating to power/weight ratio and the matter of fuel injection. Although higher cylinder pressures are used in the oil engine than in the gasoline engine, it appears established that adequate provision can be made for meeting all stresses. This can now apparently be done without having to resort to weights or construction which would limit the use of such engines to a very small field of application. The average weight is about 20 lb. per b.hp. for large types of engines, but in the case of the Beardmore, already fully tried out in practice, the weight is approximately 12 lb. per b.hp. Further, experience has proved that these constructions embody the desired degree of reliability, even when using such high cylinder pressures as are introduced with the new Beardmore engine.

The design of fuel-injection mechanism is the other important problem with which the designer is faced. The combustion chamber, the fuel-pump design, and the atomization device introduce problems closely interconnected with the establishment of the most favorable conditions for burning residual fuels at high speed. The fuel pump must measure the most minute quantities accurately and continuously. Composite fuel-pump plungers have not produced the results claimed for them. The injection period must be very definite, and the fuel must be cut off instantaneously without the slightest tendency to dribble. For that reason the connection between fuel pump and fuel nozzle must be as short as possible. On the fuel's entering the cylinder it must be in a finely divided state, and sufficiently well distributed throughout the combustion space to produce rapid and complete combustion. In certain designs the atomizer contains a spring-loaded valve under control by the pump pressure—a complication that can, however, be dispensed with.

Finally, there is the design of the combustion chamber itself. The precombustion arrangement has been introduced to avoid wall contact and to improve the turbulence. However, the success secured with the simple flat form of combustion space will probably offer sufficient inducement for designers to adopt it generally. The injection pressure, the degree of atomization, the degree of penetration, are factors in the efficient combustion of the fuel. High wall temperatures and lack of turbulence make for cracking of the oil globules, thus bringing about rapid carbonization of the cylinder walls. For this reason the distance from fuel-atomizer orifice to the point on the surface of the combustion space should be as great as possible. A simple solution consists in the introduction of two atomizers placed horizontally because the distance between atomizer and cylinder wall is equal to the cylinder diameter. The results obtained with this design have proved its practicability. (*The Automobile Engineer*, vol. 16, no. 214, Apr., 1926, p. 119.)

A High-Pressure Relief Valve

Difficulties Encountered with Valves of Commercial Design—Steps Taken in Evolving a Dependable Design—Details Regarding Materials and Processes of Manufacture

By F. A. ERNST[1] and F. C. REED,[2] WASHINGTON, D. C.

IN WORKING up designs for equipment and layout for a direct synthetic-ammonia plant to operate at 5000 lb. per sq. in. pressure, the question of suitable relief valves for the system resulted in the testing of several valves of commercial design. These tests showed that, for the higher pressures at least, the commercially available "pop" valves were not as dependable as relief valves inasmuch as they would not reseat after a relief. The design of a real relief valve was therefore considered of paramount importance.

Later, upon the delivery of the 5000-lb. compressors of one of the large manufacturers, a pop valve of the fourth stage was tested and the compressor company advised that the valve relieved at 5025 lb., its set pressure, but that it did not tighten up again. The general superintendent of the company replied, "We have had this experience with practically every make and type of high-pressure pop valve we have ever purchased (by high pressure we mean pressures in excess of 2500 lb.). In other words, we have been forced to look upon these valves as simply a safety device, and in the event that they operated, it was in most cases necessary to clean and possibly regrind the valve to make it tight."

In the event that this valve relieves, then, operation of the plant is stopped until the valve can be taken apart and reassembled. In addition, the compression is lost, as is also the gas under compression. This latter loss in the case of air is not serious, but in the case of a synthetic-ammonia plant where the gas is a 3 to 1 mixture of hydrogen and nitrogen, it is quite economically serious.

In fact, in such a case gas loss will probably receive first attention and safety second. By tightening down on the spring the valve can usually be forced tight enough against the seat to prevent leakage. This, however, destroys the object of the valve, as it can no longer relieve at the predetermined pressure, and the one-time safety valve becomes a bronze ornament, leaving the pressure system entirely unprotected.

Valve-Seat Pressures

By actual test and experience it has been found that in order to prevent leakage between the valve and the seat of a relief valve after relief, there must be a definite unit pressure exerted by the valve on its seat. With a given diameter and width of valve edge, therefore, the pressure at which relief occurs must be a definite amount in excess of the working pressure in the system. It is desirable to keep this excess in pressure as low as possible, and in order to accomplish this there must be a departure from the general rule of small equipment for high pressures. In this case the valve must be of comparatively large diameter and of narrow width of seat; i.e., the diameter of the valve is large as compared with the diameter of a pipe required to carry the same amount of gas without excessive loss of pressure by friction.

A series of tests run at 5000 lb. per sq. in. pressure showed the following results:

(1) Diam. of valve, in.	(2) Area of valve, sq. in.	(3) Width of valve edge, in.	(4) Area of valve edge, sq. in.	(5) Pressure difference (relief pressure minus reseat pressure), gage reading, lb. per sq. in.	(6) Differential load on valve calculated, lb. [(5) × (2)]	(7) Unit pressure on seat calculated, lb. per sq. in. [(6) ÷ (4)]
0.375	0.1105	0.03125	0.0368	2000	221	6005
0.375	0.1105	0.010	0.01178	640	70	6003
0.50	0.1963	0.010	0.015708	480	94	5998
1.0	0.7854	0.010	0.031416	240	188	6000
1.25	1.227	0.010	0.03927	190	233	5936
1.50	1.767	0.010	0.04712	160	283	6000

[1] Chief of Engineering Division, Fixed-Nitrogen Research Laboratory, U. S. Department of Agriculture. Assoc-Mem. A.S.M.E.

[2] Engineer, Fixed-Nitrogen Research Laboratory, U. S. Department of Agriculture.

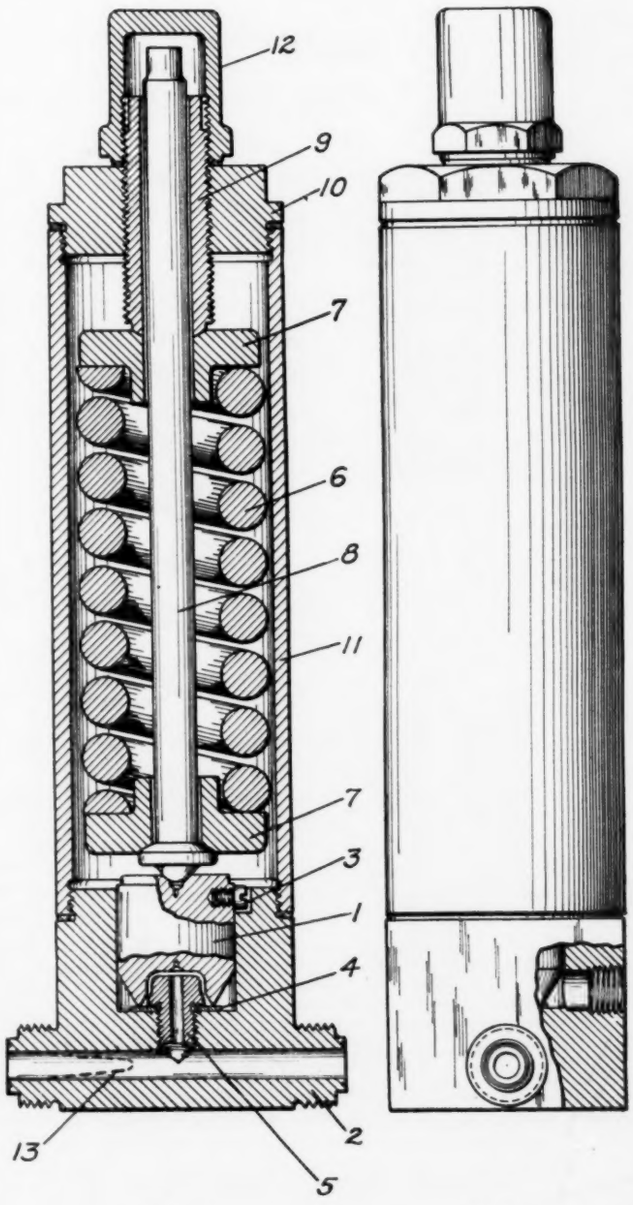

Fig. 1 Fig. 2

Fig. 1 Vertical Section Through a Relief Valve

Fig. 2 Side Elevation with Partial Vertical Section Showing Relief Vent

These tests show that a unit pressure of 6000 lb. per sq. in. is required on the valve seat in order to prevent leakage after relief occurs as well as to make a seat originally. From this it follows that

$$\frac{\text{Pressure Difference} \times \text{Area of Valve}}{\text{Area of Seat}} = 6000$$

If the most practical width of seat is considered as being 0.010 in., this expression then becomes

$$\frac{\text{Pressure Difference} \times D^2 \times 0.7854}{D \times 3.1416 \times 0.01} = 6000$$

whence

$$D = \frac{240}{\text{Pressure Difference}}$$

As an example, if it be desired to have a valve on a system operating at 5000 lb. per sq. in. pressure and a pressure differential of 150 lb. per sq. in. is allowable, i.e., the valve will be set to relieve at 5150 lb. per sq. in. pressure, then the valve diameter must be

$$D = \frac{240}{\text{Pressure Difference}} = \frac{240}{150} = 1.6 \text{ in.}$$

However, with the same conditions except that a larger pressure differential, say, 400 lb., is permissible, then the valve would have a diameter of 240/400 = 0.6 in.

While the above method is advisable for use in figuring valve diameters, it should be noted that the pressure differentials as shown are those required to seat the valve absolutely tight, so that not a single bubble, as measured by a water bubbler under a head of 1 in. of water, leaks under the seat.

This is of course a finer setting than is ordinarily necessary. It has been found that by considering half of the pressure differential as noted in column (5) as the setting pressure over the operating pressure, the leakage is so small as to still be unworthy of consideration for most operations. As an actual case in setting a 1.5-in. valve to relieve at 5080 lb. instead of 5160, the leakage at 5000 lb. pressure after relief was but a few cubic feet of gas per 24 hr., most generally not discernable without a water bubbler. For most practical or perhaps commercial purposes, then, the valves should be set at a pressure in excess of the operating pressure, a maximum of half the values as of column (5).

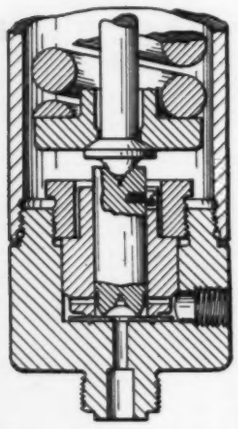

FIG. 3 PARTIAL VERTICAL SECTION SHOWING MODIFICATION

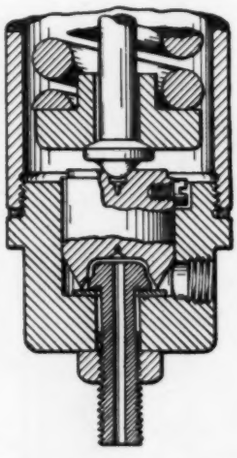

FIG. 4 PARTIAL VERTICAL SECTION SHOWING MODIFICATION

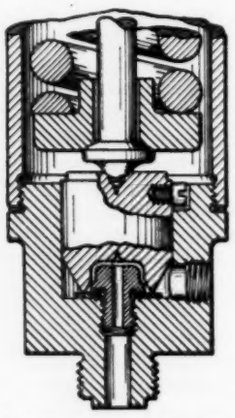

FIG. 7 VERTICAL SECTION, FURTHER MODIFICATION

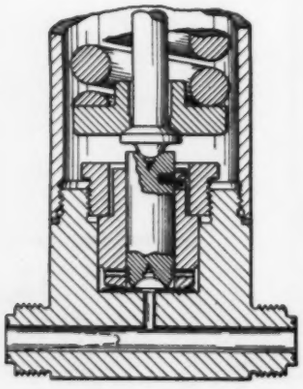

Fig. 5

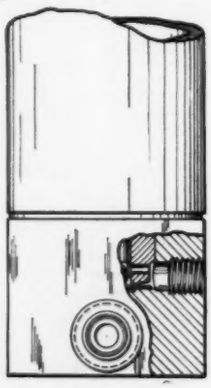

Fig. 6

FIG. 5 VERTICAL SECTION, GASKET SEAT SECURED OUTSIDE OF VALVE SEAT

FIG. 6 SIDE ELEVATION OF VALVE OF FIG. 5

DESCRIPTION OF RELIEF VALVES

In the accompanying sketches, Fig. 1 is a vertical section through a relief valve; Fig. 2 is a side elevation with a partial vertical section to show the vent for the relief; Figs. 3 and 4 are partial vertical sections to show modifications, but still using the same type of method for securing the gasket seat gastight. Figs. 5 and 7 are vertical sections of further modifications comprising a method of securing the gasket seat outside of the valve seat, while Fig. 6 is a side elevation partly in section of the valve Fig. 5, showing the relief vent.

To describe the valve briefly, 1 is the cylindrically shaped, vertically movable valve whose diameter is determined as previously described, tapered conically at its lower end to the narrow flat seat shown in the table as 0.01 in. in width. This valve is free to move vertically within the body 2, but is prevented from rotating about its vertical axis by screw 3. The narrow seat of the valve makes a gas-seal contact with the gasket seat 4, preferably of a softer material than the valve, which is secured by capscrew 5, forming a gastight joint between the annular V-grooves of the capscrew and valve body. The pressure exerted on the under side of the valve 1 within its seat is balanced by the spring 6 held between the self-aligning, ball-seated spring plates 7. The lower spring plate is carried by spring rod 8, which is movable vertically through spring adjusting screw 9, threaded into cover 10, which is held rigid by outer casing 11, threaded to body 2. The cap 12 is threaded to adjusting screw 9 over the spring rod, forming a gastight joint in order to prevent leakage of gas to the atmosphere after relief. The intake to the valve is protected by strainer 13 to prevent pipe scale or other foreign material from reaching the seat, thus preventing a perfect seal. Spring rod 8 extends above the spring adjusting screw, so that if for any reason the valve should stick, or foreign material fine enough to get through the screen should lodge under the seat, the valve can be seated by tapping this spring rod.

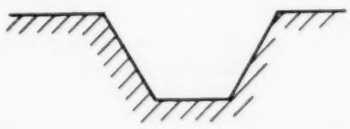

FIG. 10 CORRECT VALVE GRINDING WITH SHARP CORNERS

FIG. 11 POOR VALVE GRINDING WITH ROUNDED CORNERS

FIG. 8 VALVE EDGE, MAGNIFICATION × 60

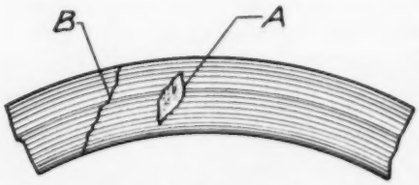

FIG. 9 IMPERFECTIONS DUE TO STEEL OR CARELESS MACHINING

MATERIALS AND PROCESSES OF MANUFACTURE

In such a piece of equipment in particular, and in high-pressure gas work in general, it is very necessary that the materials be of good quality and sound, and that these materials be accorded very careful machining.

Fig. 8 represents a valve edge (magnification × 60) which is of

good steel and has been properly machined and ground. It will be noticed that the finishing marks, not visible to the naked eye, are all concentric and that these are the only marks on the edge. If this valve is ground in a cage with any care at all, the finishing marks will be concentric. It often happens, however, that there are small imperfections in the steel or that the surface of the steel gets tool-scratched by careless machining. The results are as shown at *A* and *B*, Fig. 9 (magnification × 60). These marks, although not visible to the naked eye, prevent a positive gas seal. Mark *A* might be an imperfection in the steel or it might be gouged out by a machine tool during machining, while mark *B* might be a tool scratch or it might be a slight crack caused during hardening and tempering. The valve must be so machined and ground that a cross-section of the impression in the seat will show, at 60 magnifications, sharp corners as in Fig. 10, rather than rounded corners as in Fig. 11. This can be accomplished by using a copper disk in the grinding cage. The disk should be charged with grinding compound skimmed from the top of a mixture of oil and grinding compound. A new copper "disk" should be used for each grinding of a valve; the valve should never be finished on a surface plate or with a hone.

Upon completion of this grinding operation the valve edge should at 60 to 100 magnifications show no imperfections, and all finishing marks should be concentric with the center line of the valve as the center of these concentric marks.

In making up the valve, part 1, the valve edge, should be machined to a sharp edge and hardened and tempered. In hardening, the 1.00 per cent to 1.25 per cent carbon-steel valve should be heated to a cherry red, quenched in oil, and drawn to a light straw color. Then, using the center points as shown, the outer diameter should be carefully ground and the valve edge squared up with this outer face, leaving enough metal to finish by lapping. The lapping operation should be performed with care, using a fine carborundum (about No. 600) and finishing with rouge. With the valve held in a lathe chuck, the lapping cage should be held in the hand and the valve rotated within it by turning over the lathe. The direction of rotation should be changed frequently.

The material for the valve seat must likewise be subject to rigid microscopic inspection as imperfections similar to *A*, Fig. 9, are of frequent occurrence. The material must be close-grained and free from flaws of any kind.

Electrically precipitated copper of 99 per cent or better purity makes a very excellent seat. Other materials which have given good results are pure silver, monel metal, zinc, and Armco iron.

A valve similar to that described here was given the severe test of relieving several thousand times in succession, after which it was tested with a water bubbler and found to be tight. Several valves of this type are now in industrial use in this country, while one is in daily use on the high-pressure stage of a 3000-lb. compressor at the Fixed Nitrogen Research Laboratory, in connection with a liquid-air plant. With this valve in the line it is not necessary for an operator to be in continual attendance, for if freezing up of the liquefier occurs, the resultant increase of pressure on the compression side is taken care of by this valve.

The Testing of Milk Bottles and the Effect of Design of the Bottle Head Upon Breakage

BY F. W. KOUWENHOVEN,[1] BALTIMORE, MD.

In 1923 the author was asked to investigate the increasing breakage of bottles in a Baltimore dairy. Engineering methods of test were devised, including compression, hydrostatic, tapping, temperature, and impact tests. It was found that bottles had to follow the rules of casting, involving the use of well-filleted corners and the avoidance of abrupt changes in section. A "supported curve" type of bottle head has been designed and shown to be definitely superior to earlier types.

THE problem dealt with in this paper was originally presented to the author early in 1923 by a Baltimore dairy whose bottle breakage had increased considerably, even though they were operating a new and modern plant. He was asked to determine whether any eastern bottle manufacturer made better bottles than the one from which they purchased their supply, and incidentally to reduce their breakage.

The problem of reducing milk-bottle breakage is peculiar in that it is desired to use the bottle many times. Coupled with this repeated use is the soaking in washing-powder solutions, heating to a sterilizing temperature, cooling to the temperature of refrigerated milk, the cycle from dirty bottle to a filled, capped, and chilled container averaging approximately forty-five minutes in the modern plant.

A careful search of engineering literature failed to reveal any data on either the design or the testing of milk bottles. It was therefore necessary to devise tests. All test work has been confined to the quart bottle only, since approximately seventy-five per cent of the output of the average pasteurizing plant bottling milk goes into quart bottles, and ten per cent into pints, half-pints, and jars, while the remainder goes into cans. It is also well known that by far the largest breakage is among quarts, though the percentage losses seem to be about equal between the several sizes.

MECHANICAL TESTS

The first test employed was the ordinary compression one using a universal testing machine with the bottle in a vertical postion. The weakest bottle tested withstood a compression load of 2400 lb. before fracturing, while the strongest withstood a load of 6200 lb. The average of some thirty bottles of various manufacture was 4250 lb. A similar variation in strength is met with in practically all strength tests of glass bottles. When one thinks of the present methods of manufacturing; with the continuous tanks of molten glass, operated for months on a stretch, or until something fails about the tank itself; where the raw ingredients are shoveled into the "dog house" at the one end of the furnace and the liquid glass is allowed to flow out at the other end without stirring or otherwise mixing, it is surprising that the variations are not much larger.

It is evident that never in the ordinary life of a milk bottle is it subjected to anything like a compression load of 2400 lb., and the variations are so large as to make comparative results difficult to obtain. Therefore the vertical compression test was discontinued.

The next test attempted was the side compression test. In this test the bottle to be tested was placed between two other bottles and the three were stacked, so that the bottles themselves were horizontal, between the heads of a testing machine. This method was patterned after the method of testing ball bearings in compression. In this test, as in the ball-bearing one, the center specimen will fracture when its ultimate load is reached. This test was discontinued after ten bottles were broken, since the average load required to fracture the ten was 978 lb. and the variation was large.

A compression test of the bottle head only was tried. In this test the head of the specimen was fractured by placing it between two 1-in. steel blocks mounted on the heads of the testing machine. This test proved useful in determining that a "supported curve" type of head (Fig. 3) was far stronger than the common type (Fig. 2). It was necessary to place the specimen each time in the same relative position, since one make of bottle would prove stronger if the die marks were in the horizontal plane and other makes when the die marks were in a vertical plane. The average load required to fracture 50 specimens with the supported-curve type of head was

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1350 lb., and for the same number with the unsupported-curve type the average was 1125 lb. These specimens were of various manufacture.

HYDROSTATIC TEST

The so-called "internal hydrostatic test" was the next devised, since it was thought possible that extreme pressures would be met with when a full bottle of milk was capped on the automatic cappers. In this test the bottle was clamped in a small fixture so that the hydrostatic pressure produced by means of an ordinary deadweight gage tester could be led to the interior of the specimen.

It was found that the average internal hydrostatic pressure required to fracture 82 quart bottles of various manufacture was 185 lb. per sq. in. The hydrostatic test has proved a very satisfactory one, since it will show up a poor distribution of glass such as thin sides, thin spots, heavy bottom, and the like.

TEMPERATURE TEST

The so-called "temperature test," similar to that used by most bottle manufacturers as a test for anneal before the polariscope came into general use, was the next tried. This test has proved to be anything but a test for anneal. In the modern washing machine

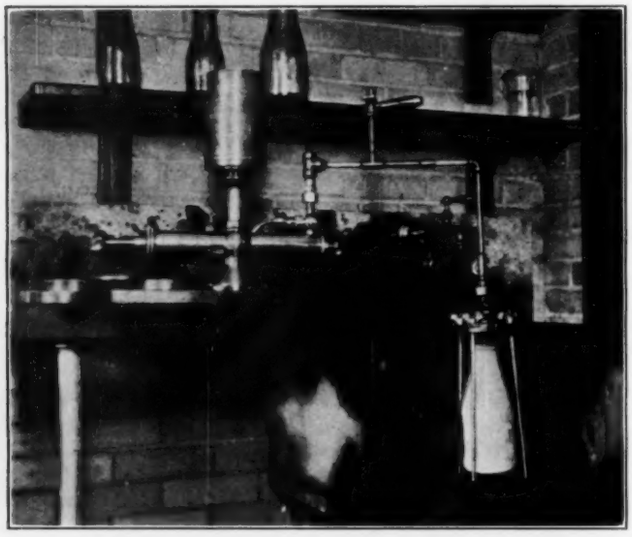


FIG. 1 INTERNAL-HYDROSTATIC-PRESSURE BOTTLE TEST

the bottle must withstand temperature changes, both cold to hot and hot to cold water. After it was determined that bottles would withstand, almost without exception, a difference of temperature from cold to hot water of over 170 deg. fahr., efforts were concentrated on the reverse test, that is, hot water to cold water. It was found that a well-annealed and well-designed quart bottle would safely withstand a temperature difference, hot to cold, of 85 deg. fahr. when working from a hot-water temperature of 150 deg. fahr. The upper temperature is important since it was found that a well-designed and well-annealed bottle would withstand a temperature difference of 88 deg. fahr. when the upper temperature was 130 deg. fahr.; while with an upper temperature of 210 deg. fahr. a difference of but 80 deg. was only reasonably safe. The manipulation in this test is important. The procedure was to allow the bottles under test to stand for four minutes immersed in water kept constant at the desired upper temperature and in circulation with a motor-driven stirrer. The bottle was then emptied as rapidly as possible, being handled by a pair of rubber-protected gas-pipe pliers, and was then thrust, bottom downward and at an angle of approximately 30 deg., beneath the surface of the cold water and allowed to fill. This test has proved useful in the determination of the proper design of both the head and the bottom of the bottle, since a bottle with too heavy a head will crack at that point, and one with too heavy or too flat a bottom will crack there.

TAPPING TESTS

Attention was then turned to the dairy itself. It was found that the approximate distribution of breakage was as follows:

Chipped-neck breakage (loss of bottle due to breakage at head and at head only)	70 per cent
(This item averages 40 per cent in those dairies using a fair type of unsupported-curve head)	
All other plant breakage	30 per cent

The large proportion of breakage chargeable to chipped necks directed us to the type of head on the bottle then in use.

In this connection it must be remembered that a milk bottle is a *cast* shape, even though formed of a so-called gel rather than of a crystalline structure such as cast iron. It should therefore follow, as nearly as is practical, one of the chief rules of casting, namely, the use of well-filleted corners and the avoidance of abrupt changes in section.

The bottle in use at that time violated this rule, since it had both sharp edges and an abrupt change in section. (Fig. 2.)

To prove that the sharp edges at the top of the head were the

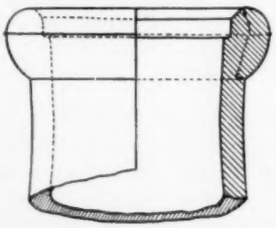


FIG. 2 "UNSUPPORTED CURVE" TYPE OF HEAD IN USE IN DAIRY PREVIOUS TO AUTHOR'S WORK

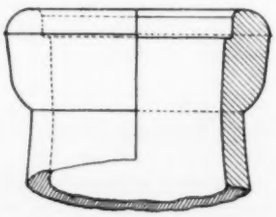


FIG. 3 "SUPPORTED CURVE" TYPE OF MILK-BOTTLE HEAD

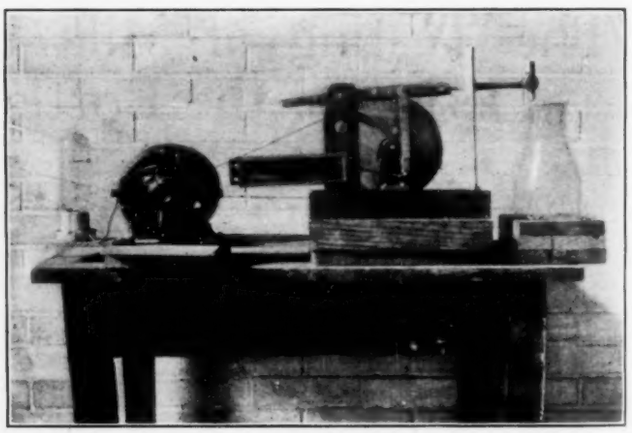


FIG. 4 TAPPING MACHINE FOR TESTING MILK BOTTLES

cause of a large number of the chipped necks, the tapping test was devised. For this test a small motor-driven cam-operated tapping machine was built (Fig. 4).

After several experiments the final machine carried an ordinary 4-oz. machinist's ball-peen hammer with its handle turned down so that the effective weight was concentrated in the head. This hammer was controlled by the motor-driven cam and was allowed to fall freely a distance of approximately 3 in. at a speed of 100 blows per minute so that its peen impinged upon the highest point of the head of a quart milk bottle standing beneath it. By means of a counter the number of blows required to fracture the head seriously was ascertained. By "seriously fracture" is meant either to break off a piece of glass of sufficient size, or to crack the head in some other fashion so as to make the bottle worthless. A number of tests on the bottles then in use showed that an average of 12 blows was necessary to fracture the head seriously. The typical fracture of this older type of bottle is interesting and important. The fracture took the approximate path shown by the dotted line in Fig. 2 running down along the center of the section area of the head, a large piece cracking off and resulting in a razor-like edge at the lower point. When the new head, Fig. 3, was designed, being in essence the old head with a rounded top section and a "supported curve," this fracture was never met with. In this new type of bottle the number of blows required to fracture the head seriously was well above 500.

No exact average can be given, since the hammer often pulverized its way into the glass without otherwise fracturing the head.

IMPACT TEST

To test the bottle further and to prove the necessity of the so-called "supported curve" section, the impact machine was adopted to bottle use. The ordinary impact machine is far too powerful, nor can a bottle be satisfactorily clamped thereto. Accordingly a small special impact machine was built, as shown in Fig. 5. This machine carried a $7^1/_2$-lb. machinery-steel ball mounted on the end of a light ball-bearing-mounted shaft. It would develop 275 in-lb. of energy when dropped from the catch position (approximately 30 deg. from the horizontal). The results given in this paper are relative only for this test, since no attempt has been made to calculate the energy absorbed in imparting velocity energy to the particles of glass when the bottle was broken. The material of which the hammer is composed was also found to be of importance. In this test it is also necessary to clamp the bottle so that the hammer will impinge upon the same relative spot on the bottle head each time. This is apparently due to the fact that bottle heads are

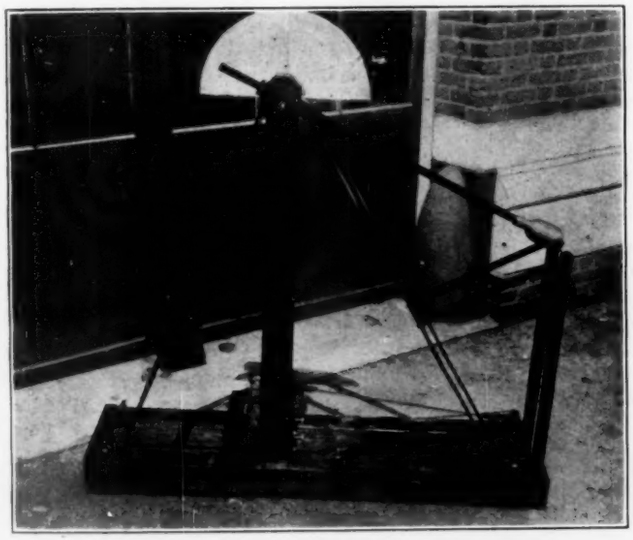


FIG. 5 BOTTLE IMPACT MACHINE

seldom exactly circular in shape and the glass is unevenly distributed around the circumference, probably due in part to wear of mold. It was found that the average amount of energy required to fracture the heads of the older type of bottle was 52.4 in-lb. The average energy required to fracture the head of the newer bottles having the supported-curve type of head was 92.4 in-lb. for those that did fracture; while one of every four bottles could not be broken even with the 275 in-lb. of energy available.

The so-called "new" bottle was put into use in that dairy during the spring of 1924. It has proved a success in reducing breakage. The chipped neck, once forming 70 per cent of the breakage occurring in that plant, has practically disappeared. No exact breakage figures can be given for either the period before or the period after the new bottle came into use. Breakage figures are one of the hardest things to obtain in a dairy, and when obtained are probably not properly segregated and are therefore not trustworthy. It can be said, though, that a second local dairy is now using the new head on their bottles.

PRESENT STATUS OF PROBLEM

The entire problem of dairy breakage is far from being solved. The breakages and losses occurring outside the pasteurizing plant itself are still large. In fact, it is at present felt that only breakage occurring within the plant is controllable, though anything done to reduce that may automatically tend to reduce the other.

The magnitude of the problem is realized when it is stated that the average number of trips per bottle is seldom more than twenty, even in the most carefully run dairy, and may in most cases fall as low as ten without arousing undue alarm among the executives.

It was stated early in this paper that in the past bottles were chosen by whim and without regard to any special feature of strength. This was forcibly brought to the author's attention during the summer of 1924 when a bottle head in use on the "store" bottles of a New York City dairy was seen to be almost identical with the special head designed for this local dairy. The store trade of that dairy totaled possibly five per cent of their total output. Their "plain" bottle head—that going to the private householder—was but little better than the older head in use in the Baltimore dairy.

It is the purpose of this paper to arouse some interest in this problem, which is in so many of its phases a purely mechanical one. Standardization of container, so far as its primary shape is concerned, is fairly well accomplished, though height of bottle, hence cream line, is still a much-discussed question. Bottle heads offer a great chance for improvement. Work here, however, must start, in many cases, with the manufacturer of capping equipment.

It has been the author's experience that bottle manufacturers are ready and willing to consider any changes suggested. The economic question met with when a change of bottle head necessitates a junking of capping equipment, particularly when only inaccurate breakage records are available, is an interesting one.

Carbon Monoxide and Automobile Exhaust Gases

IS CARBON monoxide poisoning a disease or an accident? Do small amounts produce any disease? Our general belief is that any disability consequent upon the breathing of carbon monoxide has followed an exposure producing complete inertia, if not unconsciousness, and therefore can be fixed in time of occurrence. Therefore chronic poisoning from a single exposure to carbon monoxide does not exist; persons who have not been noticeably damaged by a single exposure (unconsciousness, paralysis, acute cardiac dilation, etc.) recover from the symptoms within a few moments, and no disease is known to follow. We may be wrong in this, but if not, then carbon monoxide poisoning should be removed from occupational-disease schedules and put into accident schedules. The same should be said for caisson disease (compressed-air illness), which is apparently always an injury and not a disease.

The question arises whether other injurious products are given off than carbon monoxide from carboniferous fuels in heating stoves. One set of chemical analyses made at Ohio State University shows that, under ideal combustion, over 6 per cent carbon dioxide and less than 10 per cent of oxygen constitute the combustion products of a high-class gas-stove heater. This is a chemical condition incompatible with life for the average human being. In addition to this, we strongly suspect that other sharp and offensive substances may gradually debilitate human beings, i.e., lower their resistance, especially to diseases of the respiratory tract. The other substances found are said to be formaldehyde, acrolein, ammonia, and sulphurous products. All carbon-fuel appliances should be effectively vented to the exterior, and so constructed as not to endanger life or health. The U. S. Bureau of Standards has laid down the principles which should be followed in the construction of air-gas burners to insure complete combustion and thereby avoid carbon monoxide and other menacing by-products.

As regards the question of poisoning from exhaustive automobile engines employing tetraethyl-lead-treated gasoline, it is safe to say that none of us prefer to hazard lead in our systems if it is possible to prevent same. If, however, there is a certain negotiable amount which can be handled without accumulation and subsequent ill effects on health, and such an amount is absolutely indispensable if the economics of automotive transportation is to progress, we may have to tolerate the situation very much the same as we have to tolerate the automobile situation in general, and in spite of its manifold evils. The rational attitude of the present day is complete publicity and education regarding our manifold hazards, so that legislative and official bodies may perfect and administer regulations for safety. (Dr. E. R. Hayhurst, Ohio State University and Ohio State Dept. of Health, in *American Journal of Public Health*, vol. 16, no. 3, Mar., 1926, pp. 218–223, including a bibliography.)

Wear Experiments on Cast-Iron Gear Teeth

IN A PAPER on this subject, by Professors Guido H. Marx, Lawrence E. Cutter, and Boynton M. Green, all of Stanford University, presented at the 1925 Annual Meeting of the A.S.M.E., results of tests were reported on 30-tooth pinions and 60-tooth gears of $1^1/_2$ in. face and of three tooth forms. The inferences arrived at by the authors were that for resisting wear (1) the standard-depth 20-deg. involute tooth form is better than the standard-depth $14^1/_2$-deg. involute form; (2) the stub-tooth 20-deg. involute tooth form is better than the standard-depth $14^1/_2$-deg. involute; and (3) the standard-depth 20-deg. involute form is better than the stub-tooth 20-deg. involute. An abridgment of the paper was published in the January, 1926, issue of MECHANICAL ENGINEERING, p. 33, under the title, Some Comparative Wear Experiments on Cast-Iron Gear Teeth; the discussion, slightly condensed, immediately follows.

C. W. Ham,[1] in a written discussion, referred to a similar investigation conducted by him recently at the University of Illinois (Bulletin No. 149 of the Engineering Experiment Station) in which steel pinions and cast-iron gears of four to one ratio were used. He pointed out that in both series of tests the same pitches, and to a certain extent the same tooth forms, were chosen, and that the method of applying the load to the teeth was essentially the same. However, in the Lewis machine, which was used for conducting the Illinois tests, the torsional stress in the two shafts was obtained by means of air pressure and was obviously maintained at a constant value regardless of the amount of wear on the teeth. It appeared to him that the authors had not stated whether or not an attempt was made to determine the load on the teeth at the end of a test. Yet it was evident that with the flanges rigidly bolted together, the torsional stress was reduced after wear had taken place, resulting in a reduction of tooth load. Another point of difference that might be mentioned was the cushioning effect of the air in the Lewis machine. When compared with the effect of rigidly bolted flanges this condition might result in reducing the shocks due to irregularities in tooth spacing, since compressed air was an ideal shock absorber. According to the authors' tests, cast-iron gears when mated did not wear into the same characteristic shape as in the case of steel pinions and cast-iron gears. In the latter case the cast-iron gear showed a very decided hollowing out at the pitch line. It would be of interest to know if a higher ratio of cast-iron gears, of, say, 4 to 1 or 6 to 1, would affect the distribution of wear in the same manner as in case of the 2 to 1 ratio. It was possible that with the higher ratio the wear might be similar to that of the steel pinion and cast-iron gear of the same ratio.

Professor Ham also cited the wear results reported by E. R. Ross on automobile transmission gears of hardened steel,[2] where with hardened steel gears the wear was in all cases greatest in the region of the pitch line.

In the Illinois tests it was found desirable to measure the teeth at radial-depth intervals of 0.010 in. on account of the localized wear. The radial-depth intervals of 0.050 in. employed in the authors' tests were no doubt satisfactory, as the wear was fairly uniform over the length of the tooth profile. Information as to what were considered the limits of error in measurement and any difficulties encountered in manipulation and in maintaining the proper set-up of the ordinary gear-tooth micrometer used would be of interest. Reference to Bulletin No. 149 would show that, in so far as comparisons could be made, the results of the Illinois tests appeared to agree in a general way with the deductions made in the paper under discussion. The authors of Bulletin No. 149, however, had hesitated to draw conclusions as to the comparative wear of the several tooth forms used until more gears were tested. It should be noted that the tooth loads used by the authors of the paper under discussion were greatly in excess of loads used in normal operation of such gears, so that the allowable compressive stress of the material was exceeded immediately. It would be very desirable to make similar tests under normal operating loads, in order to find if the teeth would wear in the same manner as in the case of the accelerated tests reported.

J. M. Lessells[3] wrote that in connection with the method of applying load to the gears the authors had evidently put great faith in the possibility of the bolts maintaining the applied torque. It was difficult to imagine that this torque remained the same throughout a test. As a matter of information, Mr. Lessells wrote that he would like to have some idea of the relative movement obtained between flanges g and h (Fig. 2), corresponding to maximum load on teeth, and also whether any measurements were made after running a test by replacement of the jack and slackening off the bolts. This would have indicated whether or not the initial conditions had been maintained. The authors themselves, by their note at the end of the paper, seemed to discredit their method of applying the load. Referring to the actual results, it could be observed that the wear in test Series 3/2A was greater than that shown in Series 3/2B, although the pressure was lower and speed the same; while a similar state of affairs was observed in Series 5, test 4A showing greater wear than test 4B, although the pressure was only slightly higher. This difficulty in obtaining confirmatory data in some of the tests might discredit some of the conclusions made. Attention should also be drawn to the narrow face of the test gear employed, namely, $1^1/_2$ in. He presumed that this was chosen in order to insure uniformity in tooth pressure, but much wider faces were used in service.

G. M. Eaton[4] wrote that the tests in no sense represented service conditions, because they were all run dry, and this fact of dry running to a point of material wear might invalidate the comparisons of the various types of tooth tested. With dry gears, wear might logically be expected to start first on the flank of the driving tooth and then on the top of the driven tooth close to the point of initial contact with the driven tooth, for the following reasons, assuming perfect gears:

Under the heavy unit loads of the test, tooth deflections had a cumulative tendency to produce premature engagement of the teeth.

The sliding component of the relative motion of the driving and driven teeth was away from the pitch cylinder of the driving gear and toward the pitch cylinder of the driven gear.

Thus the tendency of the action was for the driven tooth to act as a cutting tool, gouging out the flank of the driving tooth at or shortly after the instant of initial tooth engagement, and wearing the tip of the driven tooth by a less measure in this action. Furthermore, at this point the velocity of sliding was relatively great, focusing the work of sliding friction on the tooth areas of initial contact. As the contact traveled toward the pitch point the work of sliding friction died down, vanishing at the pitch point. During the arc of recession, sliding friction built up again, but the gouging tendency was absent, being replaced by a wiping action.

This analysis was directly applicable only during the earliest stages of tooth wear with a 30–60 tooth combination, as the contours were quite promptly destroyed, the normal pitch of the driving gear being lengthened and that of the driven gear being shortened till deflection was sufficiently compensated for to greatly reduce premature contact of teeth. It now became necessary to find a mechanism for producing wear at the pitch point.

Mr. Eaton developed a theory which lined up well with the characteristics shown in the cuts of the worn gears. As the initially worn surfaces roughened, the coefficient of friction built up so that wear continued to be heavy in spite of the gradual reduction of initial contact pressure. The roughened or worn area gradually crept closer to the pitch point, and a time came when the unit pressure over the area subjected to practically pure rolling was high enough to produce a somewhat obscure destruction of the metal, which had been clearly proved at East Pittsburgh recently by the Westinghouse

[1] Associate Professor of Machine Design, University of Illinois, Urbana, Ill. Mem. A.S.M.E.

[2] Investigation of Tooth Wear with Automobile Gear Steels, *Automobile Industries*, vol. 45, pp. 865–869.

[3] Research Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa. Mem. A.S.M.E.

[4] Chief Mechanical Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Mem. A.S.M.E.

Electric & Mfg. Co. in the photoelastic laboratory. Under excessive local pressure a critical shear area was developed well below the surface of the metal. This shear was due to the elastic flow of the metal in its endeavor to escape from the region of overstrain. Shear fatigue followed, growing outwardly, that was, away from the pitch point, and a pit was finally produced by the bodily falling out of a flake of metal. This phase of the analysis was not a theory but a definitely proved action. He thought this to be the first reliable explanation of pitting to be presented to the Society.

As soon as pitting started at the pitch line, the action first described at initial engagement again set in, and wear proceeded by swinging back and forth through this cycle. In the tests set up it was to be noted that in each of them the pinion drove in one pair and the gear drove in the other pair. If the normal pitch of the pinion and gear were measurably different as cut, then inevitably there would be a difference in the initial rates of wear, even if the two sets on test were duplicates.

Mr. Eaton advanced the suggestion that the comparison of two differently proportioned sets of gears on this testing machine would be more representative of service expectations if they were based upon the number of revolutions required to produce, say, 0.001 in. of wear at whatever proved to be the first wearing area. The conditions of dry running were so fundamentally different from those of real service, where even the slightest film of lubricant existed, that he could see no merit in a comparison based on material wear under the dry condition.

In the absence of data it was not possible to determine the characteristic of the spring constituted by the quill, but it was evident that it was very steep. Mr. Eaton thought that it would be interesting to know what variation existed in the "boot strap" load on the teeth of the gear and pinion due to indexing and other errors of manufacture, and that it would be logical to introduce enough flexibility into the quill to make the load variation due to errors a small percentage of the deflection required to produce the desired torque. This would also make the load reduction due to wear less troublesome in evaluating cause and effect in the test. There was an obvious possibility that the natural torsional period of the quill and gear structure might be critical at tooth frequency or a submultiple thereof, and it would be very misleading to adopt results secured under the conditions of resonance.

Mr. Eaton did not understand why it was considered necessary to introduce the intermediate gears. While they were less undesirable here than in certain other gear tests, they were at best a disturbing element open to the criticism that they were subject to accelerations and introduced dynamic conditions which seemed unnecessary. He could not accept a single one of the "conclusions" of the paper until each was introduced with the phrase, "Under the exact conditions of the test."

B. F. Waterman[5] wrote that such short and very destructive runs as those described in the paper did not give a true measure of the wearing qualities of the various shapes of teeth. The average run lasted 8 to 9 hours; and any gear or gears that displayed such amounts of wear in that time were unduly loaded. The comparisons made might not be applicable, therefore, to gears loaded as they were in every-day practice. Mr. Waterman then referred to some tests recently made by Messrs. Ham and Huckert and published by the Engineering Experiment Station at the University of Illinois. Analyzing the wear diagrams in this Illinois paper, he did not find such differences in wear, and if the 2-in-face master pinion used where the load was 500 lb. per in. of face was considered, it was difficult to see any difference in wear. (He referred particularly to the Illinois charts, Figs. 30 and 32, where the 14½-deg. standard and 20-deg. stub teeth were compared.) In the Illinois Tests, page 50, it was stated that: "In all cases, except durability test No. 9–0, the pair of gears of 1-in. face (test gears) carrying a load of 1000 lb. per in. of face, eventually showed pronounced failure, but in no case did the pair of gears of 2-in. face (master gears) carrying a load of 500 lb. per inch. show as much as 0.001 in. wear on the cast-iron gear, or more than a few thousands of an inch on the pinion tooth." If the Lewis formula were used to calculate the strength of gears as was common practice, such load values would not be obtained, and for this reason he felt that the tabulated results, while clear, were not true measures for gear practice. Referring also to rules given in the Marx and Cutter test of 1915 and using a factor of safety of 4, values not more than one-third of those used in these tests would be obtained, and such results would be in close agreement with the recommendation of Ham and Huckert of 500 lb. per inch of face.

H. J. Eberhardt,[6] who opened the oral discussion, said that in amplifying the authors' tests it might be well to provide apparatus so that the pressure used at any time might be indicated. He thought that in running tests a definite load and a definite amount of wear should be postulated.

C. B. Hamilton[7] said that if the load fell off on test and the wear per thousand revolutions increased toward the end of the test, then it would appear that distortion of the tooth form due to wear was a very great factor in promoting further wear. The rate at which the tooth form was destroyed as distinguished from the rate at which the metal was removed was therefore a very important factor to be considered. This factor could not have been taken into consideration with the authors' machine.

Wilfred Lewis[8] asked whether the pressure on the scale was delivered to the teeth or to the blocking, as that might explain to some extent the discrepancies between the tooth load as measured by the scales and as measured by the torsional deflection of the spider ring. It could not be determined from the paper how much the pressure was reduced by the wear. He asked whether the load could be reversed.

W. R. Eckart,[9] who read the paper in the absence of the authors, in a brief reply stated that the load dropped off with maximum wear to about 70 per cent, and that calibrations were repeated at the end of the tests. The motor employed for applying the load was reversible.

AUTHORS' CLOSURE

In their closure the authors, taking up the points raised in the discussion in the order in which they first appeared, wrote that Professor Ham was the first to speak of the necessary drop-off in the load on the teeth in the type of apparatus employed, due to the relief of torsion as wear proceeded. Several others spoke of this also. This was an entirely valid criticism to which the Lewis machine did not appear to be open, as the authors presumed it was equipped with means to keep the air pressure constant in case of any leakage past the plunger. It would be a very simple matter to reset the machine, at intervals, to the original load; thus limiting the drop-off to a low value.

The authors' apparatus had certain merits of simplicity of construction and operation, as well as low first cost, which had led them, ten years ago, to its design and adoption. It had been an oversight not to include the drop-off in load, caused by the relief of torsion, in the data presented. Their whole effort in writing the paper had been directed toward the elimination of non-essentials to the ends of simplification and brevity. They had eliminated all but one variable, the form of tooth profile, and had desired to concentrate attention on this one factor. For this reason their lengthy tables of dimensions, measurements, calibrations, etc., had been omitted, as had also been detailed drawings of the apparatus and a general discussion of the subject of wear characteristics. The following table gave, in compact form, the diminishment in load per inch width of face at conclusion of each

Run	Initial load per inch width of face by platform scale, lb.	Initial deflection at spider, in.	Load corresponding to spider deflection, per inch width of face, lb.	Total wear at pitch line, in.	Drop-off in load per inch width of face, lb.
Series 1—A-A	1867	Not recorded	....	0.0175	92
A-B	1867	Not recorded	....	0.0484	253
Series 2—1-A	1693	Not recorded	....	0.0925	484
1-B	1280	Not recorded	....	0.0384	201
Series 3—2-A	1307	0.4375	2853	0.0721	377
2-B	1683	0.1875	1213	0.0172	90
Series 4—3-A	1699	0.2	1307	0.0309	161
3-B	1880	0.25	1634	0.0426	223
Series 5—4-A	2000	0.2656	1734	0.0852	446
4-B	1755	0.2188	1430	0.0466	244

[5] Brown & Sharpe Mfg. Co., Providence, R. I. Mem. A.S.M.E.

[6] Newark Gear Cutting Co., Newark, N. J.

[7] President, Hamilton Gear & Machine Co., Toronto, Canada.

[8] President, Tabor Mfg. Co., Philadelphia, Pa.

[9] Professor of Mechanical Engineering, Stanford University, Cal. Mem. A.S.M.E.

run, together with the original loads both as derived from the platform-scale readings and as computed from the angular deflections measured on the 12-in. rings of the spider. This diminishment was computed in all cases from the combined wear at the pitch circles. It was a simple matter to do this by the use of the calibration curve of the deflections measured at the spider ring plotted against the corresponding platform-scale loads. Knowing this, no effort had been made to measure the final loads on the platform scale.

It was significant to note that Professor Ham stated that, in so far as comparisons could be made, the results of the Illinois tests appeared to agree in a general way with the deductions indicated by the authors' tests. Since the Illinois tests were carried on with lighter loads, uniformly maintained, and under conditions of lubrication, his statement had a profound bearing on some of the criticisms made by those who subsequently participated in the discussion.

There would undoubtedly be some difference between an air-spring effect and that due solely to a torsional-rod spring, as in the former there would probably be no tendency toward any vibration or periodicity action, but the apparatus used by the authors could scarcely have the term "rigidly" applied to it except in some such comparative sense. In this case, at least, their conditions would seem to approximate more closely to actual working conditions.

It was always dangerous to predict, but the authors would venture to guess that the employment of greater velocity ratios would not seriously alter the characteristic wear curves, here found, so long as both gear and pinion were made of identical material. The use of dissimilar metals introduced an entirely new set of factors.

The employment of ordinary gear-tooth micrometers had been distinctly tedious, but it had been the only means of measurement at the authors' disposal. The greatest care had been exercised in taking the measurements, a magnifying glass having been used to read the verniers. All measurements used had been the averages of many readings, and the authors had had ample opportunity to become proficient and exact in the use of the instrument. Two of them had always worked together in the taking of dimensions, and if there seemed to be any doubt, they had taken independent measurements. The instrument used had been in their care and not used by any one else. In the hands of experts, variations of the order of 0.0005 in. were readily noted.

It was true that the initial tooth loads had been somewhat greater than normally employed in running and that the gears had been run without lubricant, as several of those participating in this discussion stated. As clearly pointed out in the paper, preliminary runs had been made at loads and under conditions of lubrication which had produced no measurable wear, and the authors had then proceeded to employ conditions which would produce measurable wear within a reasonable time—the shortest test, Series 2, Run 1-A, had extended over $11\frac{1}{2}$ hours of running time—since the object had been to produce wear in order to compare wear characteristics of various forms of tooth profiles under identical conditions of operation. It might be pointed out that where lubricant was employed the tests became primarily tests of the lubricant and the method of its application rather than of the properties of the tooth form, for the teeth would not wear until the lubricating film had broken down. At all events, it became scientifically impossible to separate the effects of the different factors. The authors had eliminated everything but one variable in each test, namely, the tooth profile employed. Also it might be said that the lower limit of initial load employed (1200–1300 lb. per inch width of face) was not seriously excessive for 4-pitch teeth, but was one under which they thought the teeth would stand up reasonably well provided a suitable lubricant were employed. In this regard the Illinois experiments, referred to by Mr. Waterman, again tended to corroborate the authors as they had employed a tooth pressure of 1000 lb. per inch width of face on similar-sized teeth.

Mr. Lessells was in error in supposing that the authors had depended solely upon the friction due to the bolts to hold the disks in their relative position. There had been pivoted blocks on the respective disks between which threaded members operated as struts so that no slippage of the disks could occur. These could be seen on the inside of the far disks in Fig. 1.

The maximum relative movement measured at the 12-in-diameter spider rings had been 0.4375 in., corresponding to an angle of about 4 deg. This had been in Series 3, Run 2-A, where the greatest discrepancy had occurred. The table above gave further data. A width of face of $1\frac{1}{2}$ in. was about twice the circular pitch. This did not seem narrow, as the standard rule concerning proportions for cast-iron teeth limited the maximum width of face to three times the circular pitch. This would be about $2\frac{3}{8}$ in. in this case. The teeth had worn with uniformity across the entire width.

Mr. Eaton had taken up the question of wear characteristics which the authors had purposely omitted for the sake of brevity, referring only to the comprehensive analyses of the subject by Lasche and Büchner. His explanation of the phenomenon of pitting at the pitch line, very evident in the authors' photographs and also called attention to by Lasche in his experiments, was an interesting contribution to the knowledge of the subject.

The answer to the question of how and where wear began would be found in Figs. 3 and 13, where the average depth of wear was of the order mentioned by Mr. Eaton.

With the authors' method of loading and of alternating the positions of the two types being comparatively tested, they had what amounted to the pinion of type 1 driving the gear of type 1, and the gear of type 2 driving the pinion of type 2 in one series; and the pinion of type 2 driving the gear of type 2, with the gear of type 1 driving the pinion of type 1, in the next series. The characteristics had not varied, as could be seen.

The intermediate gears had been introduced solely to reduce the speed at which the test gears had been run, as the authors had had to employ a motor and chain drive already in their possession These had been solid-disk steel gears of $1\frac{1}{16}$ in. width of face, 8 pitch, 70 and 100 teeth. At the speed employed the authors did not think there were any dynamic, or resonance, effects of any consequence. In any event, they would be identical on both sets of gears, and therefore would not effect comparative results.

A careful reading of the authors' statement of "conclusions" would show that they made no dogmatic or final claims. They said, merely, that certain deductions were indicated by these tests, and that certain forms of profile appeared to be better ones to resist wear than were certain others. These were the only comparative data known to them in which the form of the tooth profile was the sole variable. The Illinois experiments had introduced the further factors of lubricants and various rates of feeding them, as well as dissimilar materials acting together, while Mr. Ross's had been concerned only with comparisons of different materials. Actuated solely by scientific motives, the authors had undertaken only to report what they had found. If others had any further facts, agreeing or conflicting, they would be glad to learn them. Professor Ham said the Illinois results pointed to similar deductions; and these tests met Mr. Eaton's criticism directed against dry running.

Replying to Mr. Hamilton, there was no difficulty in determining the rate of change of tooth form. It merely involved periodic measurement of the teeth. To some extent the authors' figures, showing different depths of wear, showed this.

In answer to Mr. Lewis, the authors would state that their procedure in applying the load had been, first, to place a steel block between the teeth of the pinions and the base of the apparatus so that the pinion shaft could not rotate when the gear tooth pressed on the pinion tooth. The side of the pinion on which the block had been placed depended upon whether they were applying the gear-tooth pressure up or down. The direction had alternated in the experiments. Next, the load had been applied to the gear spindle by means of a lever resting on a jack on the platform scale, pressing the teeth of the spindle gear against those of the engaging pinion a definite amount; in their case just four times as heavily as the scale load, the respective lever arms being 30 in. and $7\frac{1}{2}$ in. The load reduction due to wear was given above. The load had been reversible, as had also the direction of rotation of the motor.

In conclusion, the authors extended their thanks to Professor Eckart for reading the paper for them in their unavoidable absence from the meeting.

Autogenously and Electrically Welded Boilers and Containers

By E. HOHN,[1] ZURICH, SWITZERLAND

The increasing employment of autogenous and especially of electric welding has led to an investigation of the strength and tenacity of parts welded together. The expense of this investigation has for the most part been borne by the Swiss Union of Steam Boiler Users. There are now no further obstacles in the way of employing such welded joints; for example, flanges welded on are stronger than those screwed on or rolled on, and rings welded on stiffen manhole walls much better than do those riveted on. The author proposes a new method of safeguarding welded seams by means of straps welded on, and gives examples of welded boilers, compressed-air receivers and other types of pressure vessels.

THE employment of boilers and pressure vessels having welded instead of riveted seams is increasing. Included among these are vessels whose seams must be welded because the thickness of the walls does not allow of riveting. In the case of those with thinner walls, the welding of the seams often affords other advantages, among which may be mentioned permanent tightness; further, welding is almost always cheaper than riveting.

The most efficient process of welding today is that of welding by means of water gas; with this process plates of such thickness may be welded that other processes cannot deal with them. But it is only very large works which can equip themselves for water-gas welding; medium-sized works and the trade generally are confined to oxyacetylene welding and, in recent times, to electric welding.

In oxyacetylene welding the plate is brought to a welding heat at the seam, and close to the points to be welded to a red heat. This causes the metal to expand, and during cooling stresses arise. In tests carried out in 1921[2] it was found that in a plate 22 mm. in thickness which had been heated at a spot 20 cm. in diameter to a red heat, the particles were permanently displaced as follows:

Diameter of spot measured	Contraction	Ratio
159.8 mm.	3.02 mm.	0.0189
239.6 mm.	3.17 mm.	0.0132
559.9 mm.	2.89 mm.	0.0052

The magnitude of the displacement depends on the width of the edge: the wider the plate, the greater the displacement. By annealing several times these displacements are reduced.

In local heating of this kind strains remain in the plate, and their presence was proved by cutting out strips from the plate as shown below.

Length before cutting	Permanent contraction	Ratio
l = 155.59 mm.	Δl = 0.05 mm.	$\epsilon = \Delta l : l$ = 0.00032
235.24 mm.	0.10 mm.	0.00042
555.85 mm.	0.10 mm.	0.00018

In other cases the permanent contraction was even greater. The stresses may be calculated from Hooke's law. It is true these measurements were not accurate enough for numerical conclusions to be deduced from them with absolute certainty, especially as the strips of plate had been stressed in two directions before being cut out. The stresses may be eliminated by subsequent annealing of the entire plate.

Difficulties of this kind have for the most part been overcome by electric arc welding. Here the zone of heating and the duration of heating are limited. Besides, electrically fused iron adheres better than autogenously fused iron, because the arc produces crater-like cavities in the metal which are filled by the electrically fused metal. These advantages make electric welding exceedingly suitable for welding structural parts to each other and to plates.

Among the numerous publications on autogenous and electric welding issued by the Swiss Union of Steam Boiler Users in Zurich, the following deserve attention:

Versuche mit autogen geschweissten Kesselblechen 1914 (Tests with autogenously welded boiler plates, 1914)

Versuche mit autogen and elektrisch geschweissten Kesselblechen (unter Mitwirkung des Schweizerischen Azetylen-Vereins) 1921[3] [Tests with autogenously and electrically welded boiler plates (in coöperation with the Swiss Acetylene Society) 1921[3]]

Ueber die Festigkeit elektrisch geschweisster Hohlkörper 1923[4] (On the strength of electrically welded hollow vessels, 1923[4])

Nieten und Schweissen der Dampfkessel, 1925[4] (Riveting and welding of steam boilers, 1925[4])

Tensile Strength of Autogenously and Electrically Welded Seams (Welding of Joints)

(*a*) *Autogenous Welding.* For these tests the test pieces were cut from welded plate, and were not welded by themselves. Thickness, 1.2 cm.; bars with thickened seam; V-joints welded from one side.

Cold-Bending Tests, 1914. Diameter of pin, 1.2 cm.; 52 bars, mean angle bent through, 162.5 deg.; mean radius of curvature, 1.83 cm.

Notched-Bar Impact Tests, 1914. Notch, 0.4 cm. in diameter; height over the notch, 1.5 cm.; 78 samples; mean work of deformation 5.98 m-kg. per sq. cm., mean angle bent through, 6.4 deg.

(*b*) *Electric Welding* (1923). Thickness of bars, 1.0, 1.7, and 2.5 cm.; shape of joints, *V* (Fig. 35), V* (Fig. 36), and X or double V (Fig. 37); electrodes, wound (English), paste covered (Swedish), and bare (German).

Tensile-Strength Tests. Number of test bars, 264, of which 184 were welded by using Quasi-Arc electrodes; see Table 2.

Cold-Bending Tests. Diameter of pin = plate thickness; distance of supports, 10.5 cm.; number of test bars, 264, of which 148 were welded with Quasi-Arc electrodes; see Table 3.

Notched-Bar Impact Tests. Table 4. Height of bar over the

TABLE 1 STRENGTH OF AUTOGENOUSLY WELDED SEAMS

Tensile-Strength Tests

27 bars (1914)	Fracture in seam, breaking load 2.56 tons per sq. cm.
9 bars (1921)	Fracture in seam, breaking load 2.9 tons per sq. cm.
25 bars (1914)	Fracture outside of seam, breaking load 2.8 to 3.0 tons per sq. cm.
6 bars (1921)	Fracture outside of seam, breaking load 3.4 tons per sq. cm.

TABLE 2 TENSILE STRENGTH OF ELECTRICALLY WELDED SEAMS

Plate thickness *s*, cm.	1.0		1.7			2.5		
Form of joint	*V*	V*	*V*	V*	*X*	*V*	V*	*X*
Mean value, tons per sq. cm.	>3.49	>3.70	>3.71	>3.85	3.61	3.45	3.68	3.61
Fracture outside of seam (number of bars)	3	5	2	2	1	..	..	..
Largest single value, tons per sq. cm.	4.04	4.24	4.16	4.18	4.02	4.10	4.19	4.00
Smallest single value, tons per sq. cm.	1.90	2.90	2.71	3.34	2.94	2.02	3.28	2.07

Average 3.63 tons per sq. cm. for 148 bars welded with Quasi-Arc-electrodes

TABLE 3 COLD-BENDING TESTS OF ELECTRICALLY WELDED SEAMS

Thickness of plate *s*, cm.	1.0		1.7			2.5		
Form of joint	*V*	V*	*V*	V*	*X*	*V*	V*	*X*
Mean angle of bending, α deg.	67.7	78.6	33.2	31.9	36.5	20.8	23.2	30.5
Largest individual bending angle, α deg.	180	180	57	68	75	37	37	49
Smallest individual bending angle, α deg.	12	16	17	14	14	5	11	18

TABLE 4 NOTCHED-BAR STRENGTH *K* OF ELECTRICALLY WELDED SEAMS

Thickness of plate *s*, cm.	1.0		1.7			2.5		
Form of joint	*V*	V*	*V*	V*	*X*	*V*	V*	*X*
Mean value, mkg. per sq. cm	5.3	5.0	2.9	4.0	5.3	2.7	3.4	4.0
Highest single value, m-kg. per sq. cm.	12.9	14.8	7.4	11.1	12.1	9.4	13.6	10.4
Lowest single value, m-kg. per sq. cm.	1.2	1.1	0.6	0.6	0.8	0.45	0.2	0.85

[1] Chief Engineer, Swiss Association of Steam-Boiler Users.

[2] Höhn, Tests with Autogenously and Electrically Welded Boiler Parts, page 49, Zurich 1921, Speidel and Wurzel.

Augmented text of a paper presented at a meeting of the General Union of German Steam Boiler-Inspection Associations at Karlsruhe. Translated from *Zeitschrift des Vereines deutscher Ingenieure*, January 23 and February 6, 1926, pp. 117–122 and 194–196.

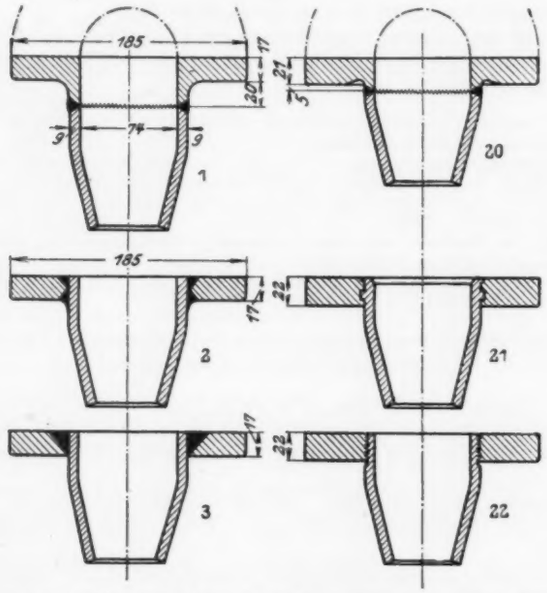
[3] Zurich 6, Speidel & Wurzel.

[4] Berlin, Julius Springer.

notch, 15 mm.; width of bars, 1.0, 1.7, 2.5 cm.; number of test bars, 417, of which 240 were welded with Quasi-Arc electrodes.

The seams of the bars tested were thickened in welding but were flattened down level before testing. The two ends of the welded seam were taken off. As to form of bars, kind of stressing, and especially as to conclusions drawn from the tests, reference should be made to the publication already mentioned.[5]

The tensile strength of electrically fused iron is high, the notched-bar strength, average, and the cold-bending strength, small. A V-seam is considerably strengthened if it is "root-welded" or welded at the back (see Fig. 36); in autogenous welding this cannot be done very well and sometimes not at all because of the double heating. On the other hand, autogenously welded V-seams may be additionally welded electrically. X or double V-joints can only be made on thick plates, 2 cm. or thicker; they have approximately the same tensile strength as the V-seams additionally welded at the root; the difference in tensile strength of thin and thick bars is small. With plates of equal thickness double V-seams show higher bending strength and notched-bar strength than V-seams and V* seams.



FIGS. 1 TO 6 VARIOUS METHODS OF FASTENING FLANGES TO TUBES

The type of electrode is very important. Wound electrodes have given best results, some bare electrodes were useless. Of the personnel employed in the tests, some were beginners; today probably better results would be obtained.

STRENGTH OF BOILER PARTS WELDED AUTOGENOUSLY AND ELECTRICALLY (1921)

Bosses, stays, and feet are welded to boilers, flanges, and tubes to an increasing extent. Such connections must be tested as to tensile strength.

Welded Flanges. The various types of flange fastenings are shown in Figs. 1 to 6. The flanges tested had the same dimensions. The testing arrangement is shown in Fig. 7. The number of test pieces was 72, and the results obtained are given in Table 5. According to this the average breaking loads are related to each other as follows:

For types	1		2		20		3
as	68.4	:	64.7	:	48.0	:	30.4
or as	100	:	95	:	70	:	44

The strongest welded joint for flanges is therefore type 1. If a flange is welded on according to type 3, then it should not be stressed except as shown in Figs. 8 to 11.

The few electrically welded flanges showed greater strength than those welded autogenously.

Since these tests were carried out new flange connections have been devised, but they can only be made by electric welding. The joints are sufficiently strong if the seams have sufficient cross-sectional area and are always given bulging profiles (never hollow ones), if the flange thickness or the distance from the seams is great enough, and if the tube wall is not less than 0.6 cm. in thickness.

Screwed or rolled flanges such as types 21 and 22, Figs. 5 and 6, are not as strong as welded flanges. They do not withstand deformation nearly as well, and with but slight deformation they lose their strength. But flanges are often overstressed, especially by tightening down nuts, and rolled and threaded flanges must therefore be thick enough so that the elastic limit of the material is not exceeded.

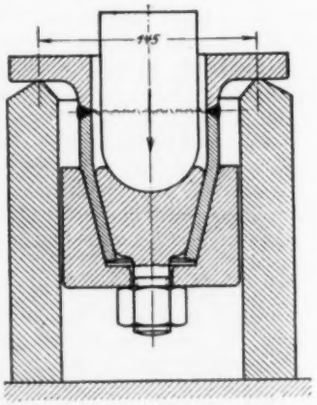
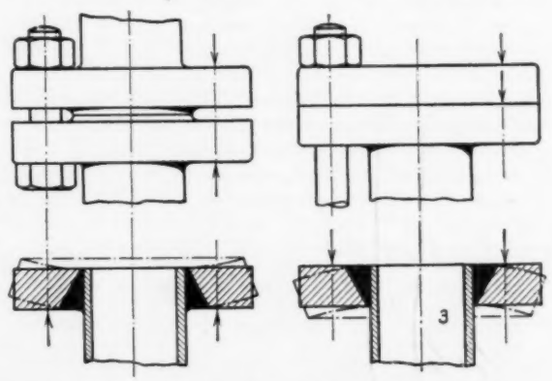


FIG. 7 ARRANGEMENT FOR TESTING WELDED FLANGES

Welded-On Reinforcing Rings. Whether it is practical to weld on a punched or unpunched disk for stiffening a plate was investigated by tests with types 4, 5, and 23, Figs. 12 to 14, with rings welded on, and with type 6 with an inserted flange or



FIGS. 8 TO 11 CORRECT METHOD OF WELDING FLANGE AUTOGENOUSLY ON ONE SIDE (TYPE 3) FOR TWO CASES OF LOADING

[5] On the strength of electrically welded hollow vessels, 1923.

TABLE 5 TESTS OF FLANGED FASTENINGS PRODUCED BY AUTOGENOUS AND ELECTRIC WELDING AND BY ROLLING AND THREADING

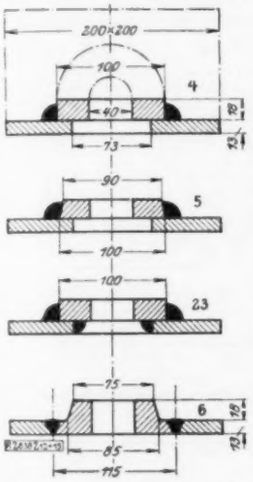
Types (Figs. 1 to 6)	Number of tests and kind of welding	Mean breaking load, tons	Maximum breaking load, tons	Minimum breaking load, tons	Mean Breaking Strength: Referred to fractured cross-section, kg. per sq. cm.	Mean Breaking Strength: Referred to 1 cm. of length of seam, kg. per cm.	Minimum breaking strength referred to 1 cm. of length of seam, kg. per cm.	Fracture
1	27 auto.	68.4	88.0	46.4	2830	2560	1740	Always in the seam
	1 elec.	80.6	...	...	3340	3010	...	In the seam
2	18 auto.	64.7	98.0	52.0	..	2190	1760	9 times in the seam; 9 times partly in the seam, partly in the tube wall
	1 elec.	64.8	...	...	..	2200	...	Partly in the seam, partly in the tube wall
3	12 auto.	30.4	46.8	24.8	..	1030	840	9 times in the seam, 3 times in the seam and in the tube wall
	1 elec.	55.0	...	...	...	1860	...	In the seam
20	4 auto.	48.0	60.0	40.0	1990	1800	1500	Always in the seam
		Mean stripping pressure	Maximum stripping pressure	Minimum stripping pressure	Mean stripping pressure referred to 1 cm. of adhering surface	Mean stripping pressure referred to 1 cm. of length of joint	Minimum stripping pressure referred to 1 cm. of length of joint	
21	4 rolled	33.05	45.0	23.4	510	1120	790	
22	4 threaded	34.92	37.8	31.5	540	1200	1080	

boss, Fig. 15, in the arrangement shown in Fig. 16—for results see Table 6. In type 4 the outer surface of the ring was cylindrical, in type 5 it was conical. The average pressures required to force off the disks were as follows:

For types	4	5	23	6
as	48.3	38.9	60.6	53.6
or as	79.7	64.2	100	88.4

The greatest strength is shown by rings welded on both sides (23) and by flanges or bosses inserted into the plate (6), but for these the plate must be flat.

As testing welded-on bosses by the forcing-off method was not sufficient, their adhesive power was further tested by elongation of corresponding test pieces, Figs. 17 to 22, the results being given in Table 7.



FIGS. 12 TO 15 WELDED-ON REINFORCEMENTS (TYPES 4, 5, 23, 6)

These tests confirm the above conclusion as to the adhesion of rings to plates. According to this, welded-on rings are effective reinforcements of holes in the walls of tanks and boilers. The rings or disks must be welded on both sides. The seam at the inner edge especially strengthens the hole in the plate, and it is therefore inadvisable to omit it. Bevel-edged rings are not desirable. The welding material must be added copiously, until the seam has a bulging profile (or cross-sectional boundary).

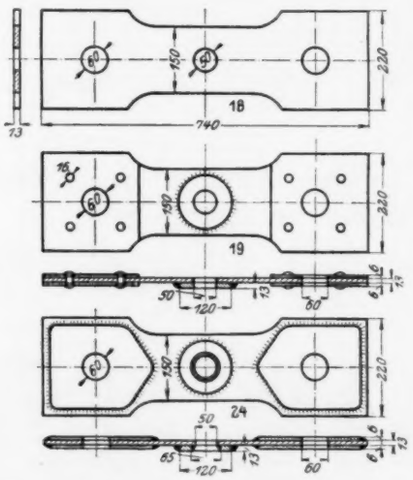
If the welding is done electrically, openings such as manholes, etc. may be reinforced by rings welded on the outside or inside (Fig. 54). In the case of thick plates there should be both inside and outside reinforcement. However, the reinforcing effect of rings thus welded on is greater than that of riveted rings. In the latter case the plate is weakened by the rivet holes, and further, the joint between the ring and plate is not very tight, and dependence has to be placed mainly on calking.

Welding of Plates Perpendicular to Each Other. In boiler construction, and even more so in building construction, the problem often is to join plates perpendicular to each other. It is possible, of course, to weld such plates electrically, and this may be permissible in building construction. Various arrangements (Figs. 23 to 28) were tested as to strength by means of the device shown in Fig. 29, the results being given in Table 8.

According to this table the comparative strengths were as follows (see Figs. 23–28):

For types	7	8	9	10	11
as	75.2	52.3	40.3	33.2	49.9
or as	100	70	54	44	67

The most reliable was type 11, the seams of which were only under tensile stress, although it did not exhibit the highest strength. Of the types under shearing stress, 7 to 9, type 7 gave the best results; in this type one of the plate edges must extend beyond the other by 2 or 3 times the plate thickness. Type 10 is inadmissible in boiler construction for important parts.



FIGS. 17 TO 22 TENSILE-STRENGTH TEST BARS WITH WELDED-ON REINFORCING RINGS (TYPES 18, 19, 24)

TABLE 6 WELDED-ON REINFORCEMENTS

Types	Number of samples and type of welding	Forcing-Off Pressure—Mean, tons	Forcing-Off Pressure—Maximum, tons	Forcing-Off Pressure—Minimum, tons	Forcing-Off Pressure Referred to Length of Seam—Mean, kg. per cm.	Forcing-Off Pressure Referred to Length of Seam—Minimum, kg. per cm.	Fracture
4	11 auto.	48.3	62.2	32.8	1540	1010	Always in the seam
	1 elec.	30.0	..	..	950	..	In the seam
5	13 auto.	38.9	67.2	17.8	1240	570	Always in the seam
	1 elec.	56.6	..	..	1800	..	In the seam
23	10 auto.	60.6	85.0	26.2	..	..	In the seam
6	26 auto.	53.6	80.0	32.0	1480	890	16 in the seam 10 in the ring
	2 elec.	51.5	..	..	1420	..	1 in the seam 1 in the ring

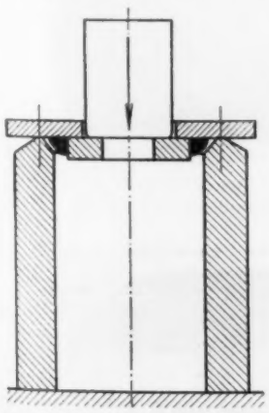


FIG. 16 ARRANGEMENT FOR TESTING WELDED-ON REINFORCEMENTS

TABLE 8 WELDING OF PLATES PERPENDICULAR TO EACH OTHER

Types	Number	Fracture	Mean breaking load, tons	Maximum breaking load, tons	Minimum breaking load, tons	Mean breaking strength referred to 1 cm. of length of seam, kg. per cm.	Minimum breaking strength referred to 1 cm. of length of seam, kg. per cm.
7	47 auto.	In one or both seams	75.2	91.6	33.0	3760	1650
	9 auto.	Outside of the seams	83.2	93.5	75.0	..	..
	3 elec.	In one or both seams	59.3	61.0	56.0	2960	2800
8	54 auto.	Always in one or both seams	52.3	68.6	22.6	2610	1130
	3 elec.	In one seam	52.8	60.6	43.0	2640	2150
9	54 auto.	Always in one or both seams	40.3	58.3	21.6	2010	1080
	3 elec.	In one or both seams	36.9	38.2	35.6	1840	1780
10	54 auto.	Always in one or both seams	33.2	66.8	19.8	1660	990
	3 elec.	In one seam	35.5	43.2	22.4	1770	1120
11	44 auto.	43 in one seam, 1 in both seams	49.9	72.2	36.5	2490[1]	1820[1]
	11 auto.	Outside of the seams	67.0	76.2	60.0	..[2]	..[2]
	1 elec.	In one seam	48.0	..	..	2400	..
	1 elec.	Outside of the seams	64.8	..	..	..	..

[1] Mean tensile strength β = 1920; minimum, 1400 kg. per sq. cm.
[2] Mean load = 2580; minimum, 2300 kg. per sq. cm.

TABLE 7 BARS WITH AND WITHOUT AUTOGENOUSLY WELDED-ON REINFORCING RINGS

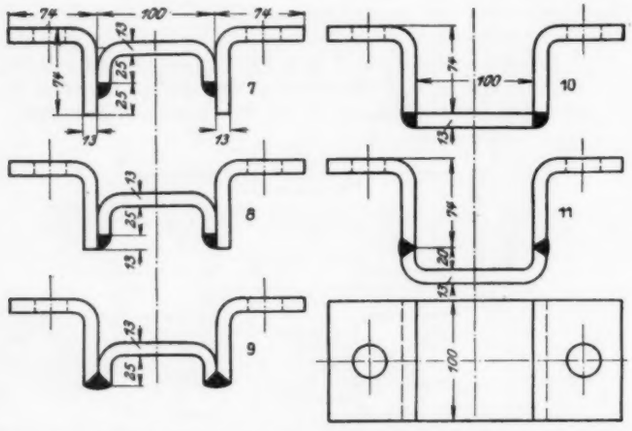
Types	Cross-Section of Bar—Width, cm.	Cross-Section of Bar—Thickness, cm.	Yield point, tons	Maximum load, tons	Fracture	Elongation of bar, mm.	Lengthwise expansion of hole, mm.
18 smooth	14.72	1.36	32.5	48.8	Not broken	From 20 to 200	From 50 to 67.8
	15.02	1.29	32.0	49.0	Fracture at hole	From 20 to 200	From 50 to 69.0
19 rings welded on outside	15.00	1.30	40.0	66.9	Fracture at head of bar	From 15 to 200	From 50 to 54.9
	15.03	1.30	43.0	68.7	Fracture at head of bar	From 14 to 200	From 50 to 54.9
	15.00	1.30	41.0	68.5	Fracture at head of bar	From 19 to 260	From 50 to 56.4
	15.00	1.35	41.0	69.8	Plate fractured in hole, ring intact at one-half of bar	From 11 to 200	From 50 to 52.9
24 rings welded on outside and inside	15.01	1.24	42 to 43	74.7	Plate fractured at hole, below ring, which is partly detached	From 19.3 to 200	From 50 to 58.3
	15.01	1.20	43.0	76.0	Fracture in one side of hole in plate and ring	From 23.6 to 200	From 50 to 60.1

Welding of Corroded Parts. In order to test the admissibility of welding of boiler plates pitted by rusting, test bars were drilled as shown in Figs. 30 and 31 and the cavities filled by welding. The mean values of the results of these tests are given in Table 9.

In this table values for the expansion and contraction have been added, although, contrary to the case of ordinary test bars, these figures because of the presence of welded seams do not really mean anything. The autogenously welded bars were curved to a greater extent than the others. Since electric welding has now attained a certain degree of perfection, such corroded areas should no longer be welded autogenously, but electrically only. However, even with electric welding the greatest caution is required; in welding fairly large areas it is best to stop occasionally so that the plate may cool down.

LAP-WELDED SEAMS AND STRAPPED JOINTS

Lap-welded test bars show a high tensile strength, but in the case of hollow cylindrical vessels, high bending stresses appear in the longitudinal seam.



FIGS. 23 TO 28 TYPES (7 TO 11) OF PLATES WELDED PERPENDICULAR TO EACH OTHER

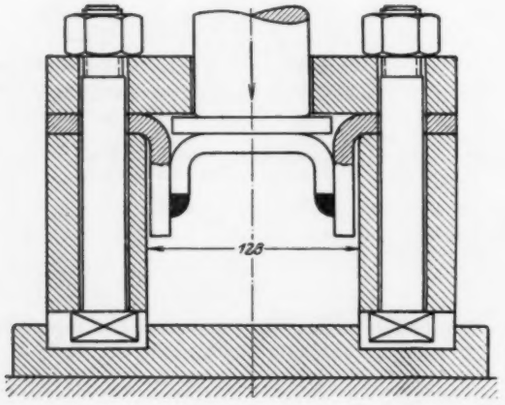


FIG. 29 ARRANGEMENT FOR TESTING PLATES WELDED PERPENDICULAR TO EACH OTHER

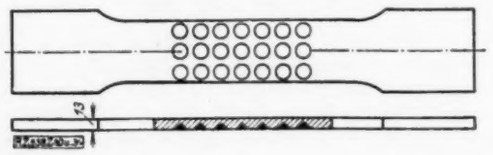
While in a lap-welded bar the two seams are stressed equally, this is not the case in longitudinal shell seams. Results of measurements[6] (Fig. 32) indicate that the greatest bending stresses occur in the seam of the exterior lap. A further proof that cylindrical shells are stressed greatest in lap-welded longitudinal seams is given by the behavior of a vessel in a pressure test which was carried to destruction, Figs. 33 and 34. Here the maximum inside diameter was 80 cm. before and 87 cm. after the test, the average plate thickness 7.9 mm., the length between outside seams 2 m. (a circular seam in the center plane is not visible), and the maximum pressure 83 atmos. The fracture ran along one of the two longitudinal seams; while the plate was ruptured in both of the seams, this took place only after a very high pressure was reached.

From this it may be concluded that lap-welded longitudinal joints should only be resorted to with caution, and only in the case of small

TABLE 9 TEST BARS DRILLED AS SHOWN IN FIGS. 30–31 AND WELDED

Types	17	13 Fracture outside of weld	13 Fracture in the weld	13 Fracture outside of weld
Number of test bars and type of welding	2 unwelded	11 autogenous	13 autogenous	1 electric
Yield point, tons per sq. cm	2.31	2.27	2.25	2.22
Tensile strength, tons per sq. cm	3.44	3.48	3.40	3.49
Contraction, per cent	59.5	56.2	35.5[1]	55.0
Elongation (20 cm.), per cent	30.2	23.1	18.3	16.1
Quality index, $\beta\lambda/100$	1.4	0.83	0.62	0.56

[1] In 4 samples.



FIGS. 30 TO 31 TEST BAR (TYPE 13) DRILLED WITH CONICAL COUNTERSINKINGS

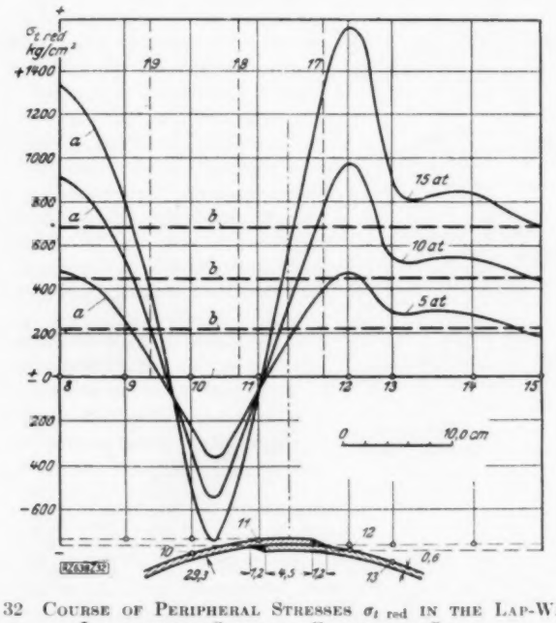


FIG. 32 COURSE OF PERIPHERAL STRESSES $\sigma_{t\ red}$ IN THE LAP-WELDED LONGITUDINAL SEAM OF A CYLINDRICAL SHELL
(*a* Result of measurement; *b* Result of calculation.)

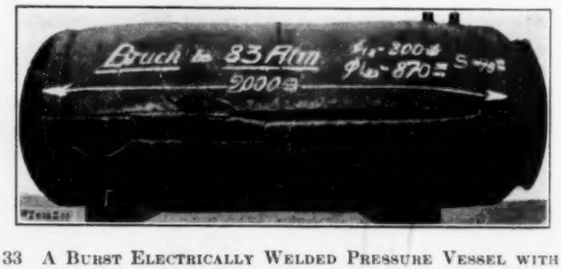


FIG. 33 A BURST ELECTRICALLY WELDED PRESSURE VESSEL WITH LAP-WELDED LONGITUDINAL SEAM

FIG. 34 ETCHED SECTION OF LONGITUDINAL SEAM AT POINT INDICATED IN FIG. 33. FRACTURE AT ZIGZAG LINE

[6] Festigkeit elektrisch geschweisster Hohlkörper (Strength of electrically welded hollow bodies), page 87.

plate thicknesses. The Hamburg Standards (1905) prescribe a safety factor of 4.75 for lap riveting by hand and 4.5 for machine riveting. According to our present observations this factor should never be less than 5 and the plate thickness should be limited. For welded vessels it should not exceed 0.8 to 0.9 cm. However, whether lap-welded joints should be used at all in boilers is questionable.

Lap-welded longitudinal seams in cylindrical vessels also make it difficult to join on the heads, the more so in the case of welded seams than in that of riveted seams.

However, the same limitations do not apply to lap-welded circular seams. Here bending stresses are not nearly as pronounced as in longitudinal seams, because both seams are stressed alike, and then only one-half as much as are longitudinal seams. For this reason the circular seams of the vessel shown in Fig. 33 remained entirely unaffected.

Straps Welded on on One Side behave similarly to lap-welded joints. Here also bending stresses appear. In one case a vessel tested under water pressure burst along the seam of a parallel strap, but only under very high stress.

Double Straps Welded On. A rectangular strap can be welded to the plate at the ends, at the sides, or all around. The behavior of such joints was tested in 108 bars altogether.

In head end welding the resistance to wrenching off is

$$\delta = \frac{Q}{2F}$$

in which Q in the breaking load in tons and F the surface area of the strap in sq. cm. In lateral welding the resistance to wrenching off (pure shearing strength in this case) is

$$\gamma = \frac{Q}{2F'}$$

in which F' is the surface area of the side.

Tensile-strength tests gave the results presented in Table 10. From these it follows that the wrenching-off strength δ and the shearing strength γ of the joints decrease with increasing thickness of strap. If the length of the side exceeds a certain amount, then fracture takes place in the straps. Such was the case generally even with straps 8 cm. in length and 0.6 to 1.2 cm. in thickness.

TABLE 10 DOUBLE STRAPS WELDED ON

Thickness of straps, cm.	δ, tons per sq. cm.	γ for length of side = 6 cm. tons per sq. cm.
0.6	2.3 to 3.3	1.66 to 2.83
0.9	2.1 to 3.1	1.59 to 2.22
1.2	1.7 to 3.3	1.33 to 2.09
1.5	1.4 to 2.6	1.2 to 1.74

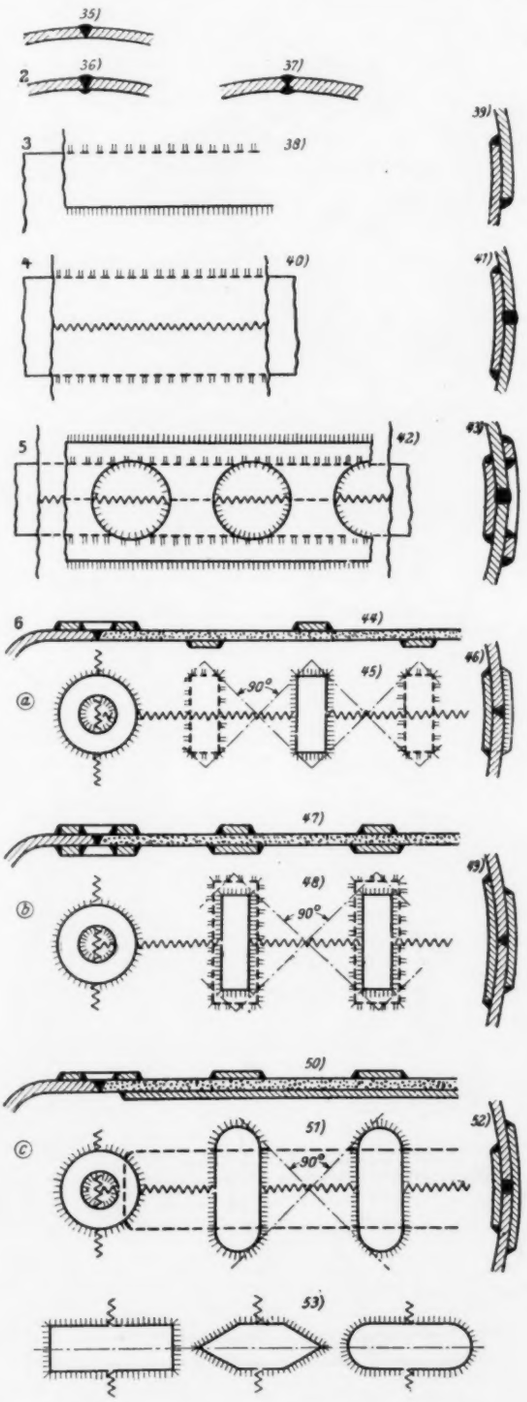
When the straps were welded on all around, they no longer broke off. Without exception the bar broke in the straps, or in case of thick straps, in the bar. The straps were 5 cm. square or rectangular (see *Zeit. Ver. Deutsch. Ing.*, vol. 69, 1925, p. 1169, Figs. 14 to 21). For steam boilers and other pressure vessels they should be rectangular, when they will have the requisite adhesive power, even if the welding of the seams is not quite free from defects.

MANUFACTURE OF AUTOGENOUSLY AND ELECTRICALLY WELDED BOILERS AND OTHER PRESSURE VESSELS

One of the simplest problems in constructing pressure vessels is that of joining a cylindrical shell securely to two heads, which involves one longitudinal and two circular seams. The heads must be provided with a cylindrical prolongation or flange or skirt. Although this is well known, there are those who still believe at times that they can dispense with flanges or skirts. The fact that such joints are dangerous is evident from explosion statistics. The flanges or skirts must also be sufficiently broad. The best contour for the heads is a circle; the next best an ellipse, a ratio of 2:1 of the semi-axes being sufficient.[7]

In autogenous welding the seams are generally only welded on one side, for the seam and neighboring zones of the plate suffer if repeatedly heated. For the joint rarely any other form than the V-shape is considered. The seams are thickened on the outside as much as possible. If it is desired to reinforce the longitudinal seam by means of straps, they must be welded on electrically.

In electric welding the seams may be welded either on one or on both sides, as the seam does not suffer from additional heating due to welding over a welded seam. For thin plates the V-shape of seam is used, and for thick, the double V-shape.



FIGS. 35 TO 53 VARIOUS METHODS OF WELDING LONGITUDINAL SEAMS ELECTRICALLY

The seams of a pressure vessel can be welded on both sides only if the interior of the vessel is accessible; but longitudinal shell seams are always accessible on both sides, because the shell may be welded by itself.

A longitudinal seam may be welded electrically by the following methods (see Figs. 35 to 53):

[7] See Ueber Festigkeit elektrisch geschweisster Hohlkörper, pp. 53, 61 and 111, and *Zeit. Ver. Deutsch. Ing.*, vol. 69 (1925), p. 155 and p. 367, also vol. 70, p. 163.

1 The V-shape seam, is welded only at the open side, Fig. 35.

2 The seam is welded on both sides, i.e., the V-shape is subsequently-welded at the root, but with thick plates double V-seams are necessary, Figs. 36 and 37.

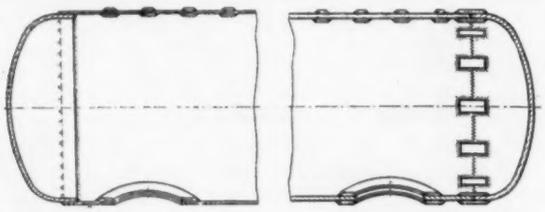
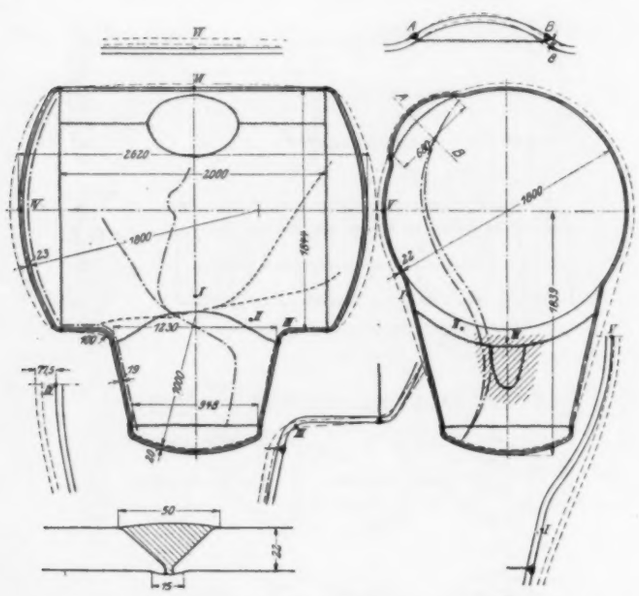


FIG. 54 TWO METHODS OF ELECTRICALLY WELDING A PRESSURE VESSEL



FIGS. 55 TO 62 PRESSURE VESSEL WELDED AUTOGENOUSLY BY SULZER BROTHERS A-G., 1919

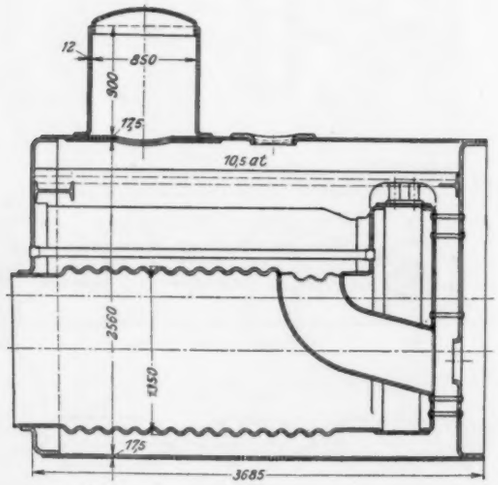


FIG. 63 BOILER BUILT BY ESCHER, WYSS & CO., ZURICH, WITH KING FLUE AUTOGENOUSLY WELDED IN

3 The seam is lap-welded, Figs. 38 and 39.

4 A strap is welded on at one side of the seam. In this case the edges of the plate must be welded to the strap in the joint; Figs. 40 and 41.

5 Welding a strap on one side and a second strap with openings, the edges of which are welded on at the other side,[8] Figs. 42 and 43.

[8] See "Uber Festigkeit elektrisch geschweisster Hohlkörper," pages 53, 61 and 111, and vol. 69 (1925), p. 155 and p. 367, also vol. 70, p. 163.

6 The seam is reinforced by means of transverse straps, the possible methods being *a*, *b*, and *c* in Figs. 44 to 53.[9]

In lap welding the plate surface is injured to a certain extent at the seams; originally tough material is fused out and replaced by brittle welding material (see Fig. 34). Such a fusing-out process along the seam must weaken the cylindrical shell. By using transverse straps these objections are eliminated. From the standpoint of elasticity the arrangements in Figs. 47 to 49 are free from objection, provided the transverse straps are not too far apart. Seams in plates of considerable thickness may be reinforced in this manner. The arrangements shown in Figs. 44 to 46 are only applicable to thin plates (0.8 to 1.0 cm.). In those of Figs. 50 to 52 parallel and

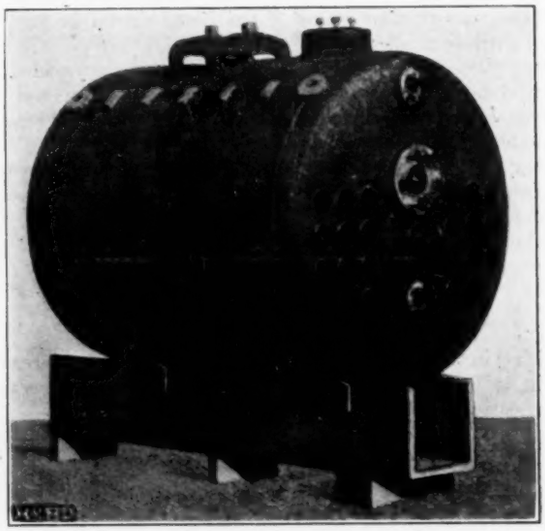


FIG. 64 ELECTRICALLY WELDED TUBULAR BOILER, SWISS LOCOMOTIVE AND MACHINE WORKS, WINTERTHUR

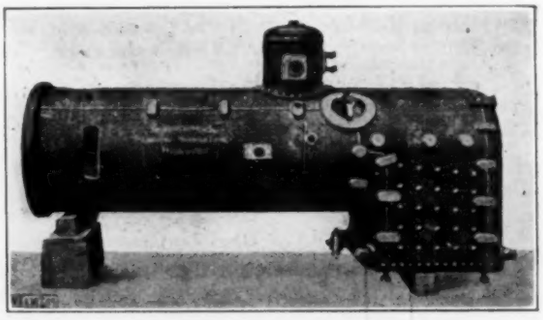


FIG. 65 BOILER FOR A STEAM ROLLER WELDED ELECTRICALLY BY THE SWISS LOCOMOTIVE AND MACHINE WORKS

transverse straps may be welded on simultaneously. The transverse straps then neutralize the bending stresses caused by the parallel ones. In the case of cylindrical shells, which are circular at the longitudinal seam, the transverse straps serve to prevent the appearance of dangerous bending stresses by increasing the moment of resistance.

The distances between the straps as shown in Figs. 45, 48, and 51 may be determined by taking into consideration the shearing stresses that arise in the plate of a cylindrical shell as soon as the tangential stresses are partly taken up by the transverse straps.

Circular seams may also be welded by the methods shown in Figs. 35 to 53; but for circular head seams methods 4 and 5 are rarely employed in practice, because usually the heads do not have flanges of sufficient width (see Fig. 54). If a vessel is not accessible inside, then only seams like that of Fig. 35, with possibly straps welded on one side, are practicable.

Cylindrical vessels which are welded electrically must be so designed that their strength can be guaranteed even when the welded

[9] German Patent No. 377,066.

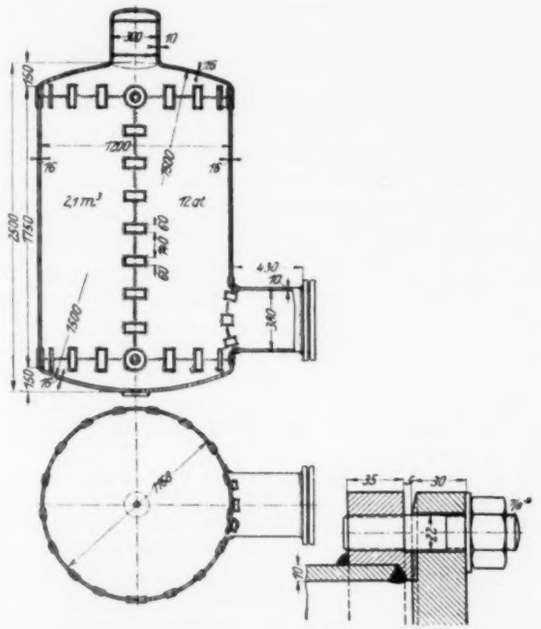
seams are not entirely free from defects. This may be accomplished by the employment of transverse straps. In thick plates circular seams may also be thus reinforced; for thin plates lap-welded circular seams suffice (Fig. 54).

EXAMPLES OF BOILERS AND OTHER PRESSURE VESSELS IN WHICH WELDING HAS BEEN EMPLOYED

A rather large experimental apparatus constructed in 1919 in the shops of Gebrüder Sulzer A. G. at Winterthur, is an autogenously welded T-tube for turbine piping, Figs. 55 to 62. Midway along the longitudinal seam a dished plate AB was welded in, the behavior of which under high pressure was to be observed.

In the hydraulic test permanent deformations appeared which are indicated by broken lines.

At a pressure of 68 atmos. a small crack appeared at point III. Up to this pressure the container had remained tight. A triangular piece of plate was then welded in, see Fig. 60. During the third test a large crack appeared at 70 atmos. which started from point III and ran along the plate of the head. Simultaneously other cracks appeared which ran all over the plate. The cylinder expanded to 187.5 cm. in diameter, and the tangential load on fracture was 2980 kg. per sq. cm., $z = 83$ per cent. This comparatively low figure must be attributed to the bending stresses, which appear where the wall is flat. The cross-section of a seam is shown in Fig. 62. In the joint the plate edges and filling material were hammered until the root of the joint projected above the plate surface; it was then chipped off.



FIGS. 66 TO 68 ELECTRICALLY WELDED BOILER DESIGNED TO EMPLOY ELECTRIC HEATING AND BUILT BY WARTMANN, VALLETTE & CO., BRUGG (SWITZERLAND)

On Lake Zurich four marine boilers built by Escher, Wyss & Co. and equipped with King flues have been in operation for 13 years. These tubes were welded up in water gas or in the fire, but were welded autogenously into the boiler (see Fig. 63). So far no defects have been noticed. The seam at the top of the firetube, however, is under bending stress, because the cross-section of the firetube is not complete at that point.

Fig. 64 shows a small tubular boiler that was entirely welded electrically. Its inside diameter is 1010 mm.; inside length between heads, 1250 mm.; thickness of plate, 10 mm.; operating pressure 8 atmos.; heating surface 10 sq. m. The longitudinal seam is reinforced by straps which are welded on the inside and outside. For bracing the heads, stays are added inside, which are welded to the wall and to each other and are again reinforced by straps. The cross-section of the straps welded on is approximately 50 per cent of the longitudinal section of the seam. The boiler of a steam roller, Fig. 65 (operating pressure, 12 atmos., heating surface 9.5 sq. m.; shell diameter, 656 mm.; plate thickness, 8 mm.), has been welded electrically, with the exception of the seams of the dome and the firebox frame, which are riveted. Most of the welded seams are reinforced with straps.

Figs. 66 to 68 show an entirely electrically welded steam boiler designed to employ electric heating; volumetric capacity, 2.1 cu. m.; operating pressure, 12 atmos. Reinforcing straps have been welded on all of the seams, even on those of the heads, whose flange radius is fairly small, because the effects of narrow flanges extend into the circular seams. One advantage of welded boilers is that their heat-insulating covering need never be broken, because the boilers are tight permanently and the outside requires no attention. The seams may be controlled from the inside, because they are not covered by straps. Further examples of welding work are shown in Figs. 69 to 71. In the boiler, Fig. 69, the strap cross-section is 25 per cent, and in the compressed-air receiver, Figs. 70 and 71, it is 28 per cent of the longitudinal section through the unthickened longitudinal seam.

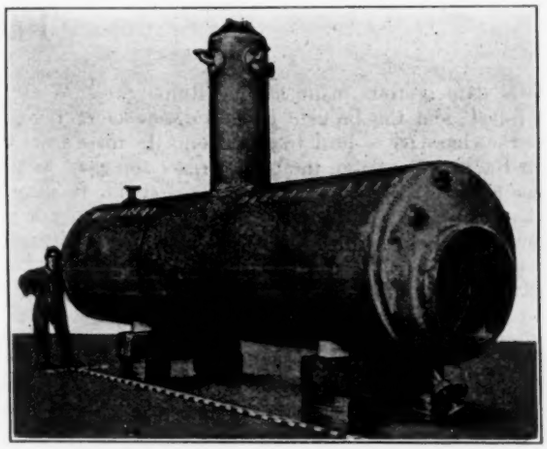
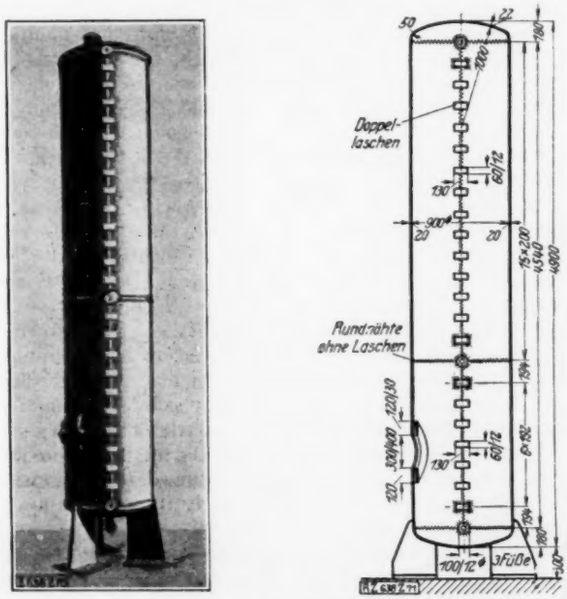


FIG. 69 ELECTRICALLY WELDED CORNISH BOILER BUILT BY THE SWISS LOCOMOTIVE AND MACHINE WORKS. HEATING SURFACE, 40 SQ. M.; OPERATING PRESSURE, 13 ATMOS



FIGS. 70 AND 71 COMPRESSED-AIR RECEIVER BUILT BY THE SWISS LOCOMOTIVE AND MACHINE WORKS. CAPACITY, 3 CU. M.; OPERATING PRESSURE, 30 ATMOS.

Doppellaschen = Double straps
Rundnähte ohne Laschen = Circular seams without straps
Füsse = Feet

All of these pressure vessels have been welded with direct current and with best English wound electrodes.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

What Is Known Today Regarding the Nature of Heat Transmission

IN 1924 data of tests made at the Rhine Steel Works were published, and this brought about a discussion on the question of the true character of heat transmission. In these tests the figures for the heat flow from the blast-furnace top gases to the wall of a pipe 1.2 m. (47.24 in.) in diameter were found to be surprisingly small as compared with previously observed coefficients of heat transmission in open-hearth furnaces and high-efficiency boiler plants. Numerous attempts to reconcile these figures with other observations failed for various reasons. Not only this, but within the last few years it has been found that certain so-called laws, the validity of which was previously fairly universally assumed, do not work in practice.

It is with this in mind that the author (himself a prominent investigator in thermodynamics in Germany) attempts to present a survey of our present knowledge concerning flow of heat, and does this primarily by expressing the fundamental conceptions governing these phenomena rather than by attempting to give actual numerical values or formulas.

The question of the mode and nature of heat transmission from a flame, hot gases, or hot air to an object being heated could not be answered until it became possible to establish the simultaneous occurrence of four processes and to separate the effects of these processes from each other. These processes are heat conduction, convection, radiation from pure gas, and radiation from finely distributed particles and vapors in the gas. A whole series of carefully conducted investigations within the last few years failed because their authors mistakenly accepted the general validity of the so-called Nusselt law (in accordance with which heat transmission through convection, beginning with a certain velocity called critical, increases with the 0.8 power of the velocity), while totally neglecting other important factors and of course, arrived at wrong conclusions.

In the present article the author undertakes at first to consider the individual processes exerting an influence on heat transmission, and begins with heat transmission by conduction. He conceives this process to take place in some such way as by a stream of warm air flowing uniformly and without internal eddies through a smooth pipe, or that perfectly still air is confined in a totally enclosed space. In both cases the heat of the air is assumed to be transmitted to the walls of the pipe or enclosure solely through the heat conductivity of the gas.

It is significant, in actual practice, that such a process cannot take place in the way described. In a closed room turbulence will be created by the inevitable upward flow of air, and the same thing will happen in the case of the flow of gas through a pipe, because of the roughness of the walls that is always present in actual engineering structures; this latter might be called technical turbulence. As a result of this, new gas particles are all the time brought into contact with the walls, and the heat conductivity of the gas becomes of secondary importance when compared with the heat exchange through contact usually described by the term "convection." This has been studied by Nusselt, who claims that the heat transmission by contact above a certain velocity called "critical" is dependent upon the velocity of flow of the gas, the diameter of pipe, the coefficient of heat transmission, and the temperature, the coefficient of heat transmission increasing with the 0.8 power of the velocity of flow of the gas.

It is unfortunate that Nusselt's work was accepted for cases lying beyond its legitimate field, as this delayed further progress for a decade. We know today, however, that the so-called Nusselt law is strictly applicable to heat transmission from air to furnace walls or pipes at all temperatures and for heat transmission from flue gases up to temperatures of 500 deg. cent. (932 deg. fahr.) but not beyond. The so-called "critical" velocity which Nusselt located at about 1 m. (3.28 ft.) per sec., is, according to modern investigations, considerably higher, namely, 4 to 5 m. per sec. (13.1 to 16.4 ft. per sec.). As a result we may consider the coefficients of heat transfer constant when dealing with transmission from brick to air or with conventional types of recuperators or regenerators working with velocities common today or with economizers. The case is entirely different, however, for flue pipes of boilers utilizing the waste gas of gas engines, or in the high-duty heating service of modern air preheaters such as the Ljungström and others.

The increase in heat transmission with the 0.8 power of the velocity of gas flow is observed in a suction pyrometer when an attempt is made to raise the heat transmission through contact by the greatest possible increase in the velocity of flow and to do it in such a manner as to secure the nearest approach of the temperature of the brazed section of the thermoelement exposed to radiation to the temperature of the gas.

Contrary to the data of measurements carried out in this connection by Unger (*Archiv für Wärmewirtschaft*, 1924), the new and as yet unpublished investigations of Wenzell (G.H.H.) show that with a suction pyrometer even when the velocity of gas flow is increased to that of sound, one can measure only from 60 to 70 per cent of the temperature difference actually obtaining. Our measurements are therefore always either below or above the true gas temperature.

As stated above, the Nusselt formula in the light of these limitations holds good in the case of flue gases only up to about 500 deg. cent. (932 deg. fahr.). Above this the results are more and more affected by influences due to radiation effects of certain kinds of gases. These phenomena of heat transmission through gas radiation can attain such magnitudes as to exceed many times the heat transmission through conduction and convection.

Before proceeding to discuss the nature of radiation from gases, the author considers briefly the whole subject of heat exchange by radiation, and restates the Stefan-Boltzmann and Kirchhoff laws. These need not be referred to here as they have already been covered in another abstract in MECHANICAL ENGINEERING (Dr. Alfred Schack, New Data on Heat Radiation, vol. 47, no. 7, Jan., 1925, p. 41–44).

The great difficulty in the investigation of phenomena of radiation where gases are concerned lies in the presence of factors which make precise measurements difficult to obtain. Recent investigations have shown that changes in roughness of metal surfaces and the presence of smooth coatings of slag and oxide on these surfaces influence the results to a marked degree. Oxides, in particular, reduce the radiation coefficient materially.

Furthermore, the light effect as perceived by the eye does not constitute a positive measure for either the energy radiated by a body or for the temperature of the body. Optical pyrometers which have been employed to determine the surface temperatures of bodies in an endeavor to measure radiation suffer materially in their precision from the variable degree of emissivity of the body under measurement. Not only do very slight contaminations of air, for example, by smoke, lead to material errors in measurement, but the reflection of the heat radiation of a hotter wall by colder one may (as has been established by very recent and as yet unpublished investigations) lead to an excessively high-temperature, showing when a measurement of the colder wall is attempted;

nor can any help be obtained in such a case as this by making corrections by such means as Shook's scale or similar tables.

The author considers next the case of a totally enclosed room and imagines it to be filled not with air but with carbon dioxide. He assumes next that a plate in that room is heated and that the temperature range is determined. It is found that under such conditions the heated plate attains a lower temperature with the same supply of heat than would have been the case if the room had been filled with air, in addition to which it is found that the carbon dioxide is quite perceptably heated.

The plate to be heated receives heat radiations of certain definite wave lengths while letting all others through, and CO_2 absorbs these latter, while air does not. It so happens, furthermore, that the properties of carbon dioxide, in particular its ability for radiation and absorption, are also common to those gases with which engineers have to deal as products of combustion, namely, carbon monoxide, water vapor, and the light and heavy hydrocarbons.

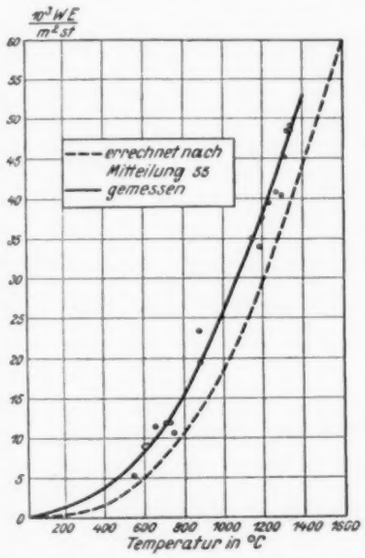


FIG. 1 RADIATION FROM A GAS LAYER 1.23 M. THICK (48.4 IN.) CONTAINING 21 PER CENT CARBON DIOXIDE AND 2.4 PER CENT WATER VAPOR

(*W.E.* = large calorie; *st.* = hour. Broken line: calculated in accordance with process described in publication 55 (possibly 65) of the Düsseldorf Heat Institute, solid line: measurements.)

All the above facts have for a long time been familiar to workers in pure physics and measurements have been made of wave lengths and radiation intensity, only, however, up to temperatures of 900 deg. cent. (1652 deg. fahr.). The bands of wave length have been also determined within which particular gases are capable of absorbing or radiating heat. It is of interest to note that Frederick von Siemens pointed out the importance of these facts, but for forty years the matter was wholly neglected. It was only in 1922 that the present author on the basis of careful laboratory tests again called attention to the importance of gas-radiation phenomena in the transmission of heat from furnace gases. At approximately the same time the Düsseldorf Heat Institute took up the same question, and it was Dr. Schack of that organization who analytically established that within temperature regions above 500 deg. cent., the heat transmission in the case of the gases mentioned above is primarily controlled by phenomena of radiation, which gave a scientific explanation of the hitherto unexplained high coefficients of heat transmission in boilers and furnaces.

In Fig. 1 the broken curve shows to what extent the radiation of a gas column 1.23 m. (48.42 in.) in diameter containing 21 per cent carbon dioxide and 2.4 per cent water vapor must increase with the rise in temperature in accordance with Dr. Schack's theory. Because of the many doubts raised by the publication of Dr. Schack's investigations the author in collaboration with Engr. Thomas carried out certain tests on an experimental furnace fired with blast-furnace top gas. The difficult problem of determining heat radiation from gas without having the results affected by heat transmission through conduction and convection was solved in what seemed to be the only possible way, namely, by providing means which made it possible to see right through the experimental furnace. Fig. 2 shows the scheme of the experimental installation. The two large openings located opposite each other enable one to see right through a column of the gas. If the gas radiates heat this will be indicated by a properly arranged bolometer acting as the heat-measuring device. The size of the openings in the walls was so chosen as to prevent even the smallest radiation from the walls from reaching the field of vision of the bolometer. Further to exclude all foreign radiation the bolometer was enclosed in an air-tight manner at the base of a container 70 cm. long (27.55 in.), provided with water cooling and having its inner surfaces blackened with soot.

In order to avoid disturbances due to variations in the thickness of layers of the gas column due to variations in chimney draft, the opening opposite to the bolometer was closed by a water-cooled soot-blackened box. A suction pyrometer (illustrated in the original article) was used for an approximate determination of the true temperature of the gas column, and proved to be quite serviceable.

Several calibration tests were made with a flow of hot air through the experimental furnace in order to determine the minor disturbing factors affecting the operation of the bolometer. With this arrangement and blast-furnace top gases for fuel, all that the bolometer measured was the heat radiation from the gas column.

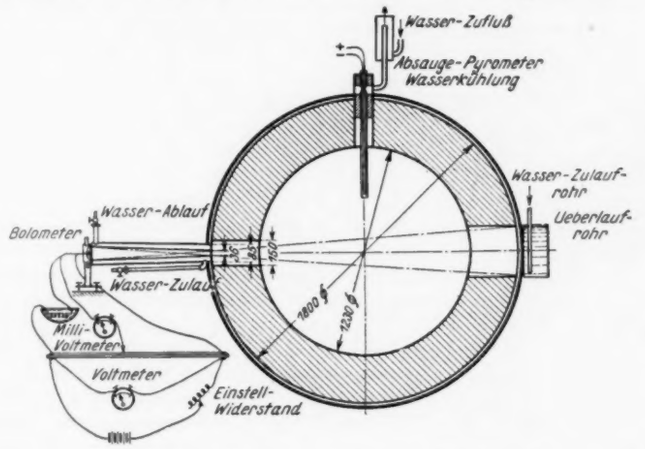


FIG. 2 EXPERIMENTAL FURNACE INSTALLATION

(*Wasser-Zufluss*, water inflow; *Absauge Pyrometer Wasserkühlung*, water cooling of the suction pyrometer; *Wasser-Zulauf-Rohr*, water inflow pipe; *Wasser-Ablauf*, water exit; *Ueberlaufrohr*, spillway pipe; *Einstell-Widerstand*, adjustable resistance.)

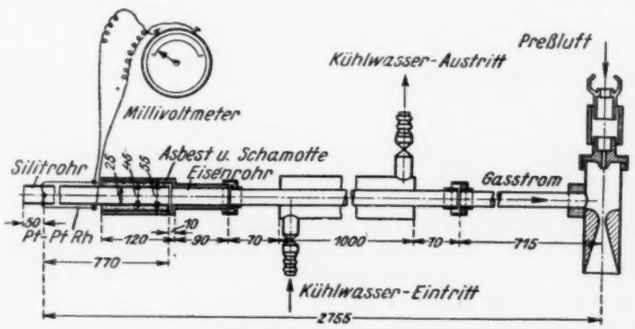


FIG. 3 SUCTION PYROMETER

The data of this are given in the solid curve of Fig. 1, which shows how the results of measurements approach the curve previously determined by a different method of Schack. The fact that the curve obtained by actual measurements lies about 10 per cent above the one obtained analytically may be for the most part explained by the fact that Schack in his calculations always used the smallest coefficients known to science, in order to be on the safe side, and that for reasons explained elsewhere the gas temperatures as indicated by his measurements were always a little too low.

While these tests were going on, data of other investigations became available and were found to confirm the results indicated above. Such are the investigations of Dr. Moeller working at the Research Laboratories of the Siemens & Halske Company, and those of Dr. Heiligenstädt, of Rheinhausen, and of Engr. Goebel working at the Julien Iron Works.

An investigation carried out in a manner similar to that described above on a 70-ton open-hearth furnace gave, however, results which would indicate that in addition to pure heat radiation from the gas other forces thus far unknown are at play. The measurement of heat radiation from the gas where the latter

consisted of a mixture of coke-oven gas and blast-furnace top gas in one case and in the other coke-oven gas and producer gas fired in an open-hearth furnace, gave values as high as 100 per cent above those which one would expect from Schack's calculations.

In order to clear up this new puzzle, another series of tests were made with the experimental furnace. In these tests an injection of benzol was used to obtain a strong soot formation and to have the blast-furnace top-gas flame permeated with soot. Bolometer measurements gave for such a thoroughly sooted-up flame practically the same values of radiation as would have been obtained from a so-called black body of the same temperature as the flame. Measurements of the temperature of these flames impregnated with particles of soot made with an incandescent-filament pyrometer gave values in close agreement with those obtained by the suction pyrometer. For an explanation of this phenomenon the author refers to American measurements that were carried out in the interest of the incandescent-lamp industry on wires of decreasing diameters. These tests indicated that as the diameter of the wire decreases the heat transmission through contact rapidly increases. Similarly in this case the author comes to the conclusion that as a result of contact with matter of high heat transmissivity the heat of the flame is given up to the fine particles of soot and transmitted by these latter by radiation, probably in accordance with the Stefan-Boltzmann law. In this connection attention may be called to the fact that the luminosity of a luminous flame in itself has nothing to do with its ability to radiate, and the fact that accidentally in the case under discussion the two happen to occur simultaneously should not lead to false conclusions. A confirmation of the very high coefficients of heat transmission from soot-charger gas is given by the curves in Fig. 4 representing measurements of temperature in the air and gas chambers of an open-hearth furnace. In the gas chamber there was found, during the period of gas flow, a close approach of the temperature of the gas to the temperature of the bricks.

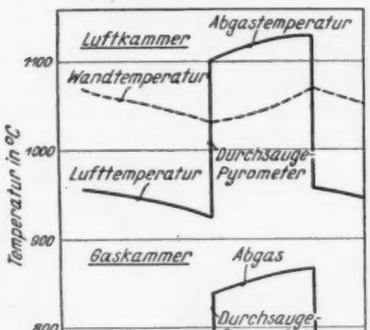


Fig. 4 Temperature Measurements in the Air and Gas Chambers of an Open-Hearth Furnace

(*Luftkammer*, air chamber; *Abgastemperatur*, exhaust-gas temperature; *Wandtemperatur*, wall temperature; *Lufttemperatur*, air temperature; *Durchsauge-pyrometer*, suction pyrometer; *Gaskammer*, gas chamber; *Frischgas*, entering gas; *Zeit*, time.)

An effort was made to work out from these tests processes that would be of practical use, in particular to improve the heat transmission from gases by their "inoculation" with oil or tar. In the course of these tests it was found that the effective method of inoculating is that in which the carbon is in the state of the finest subdivision, and that inoculation with coal dust does not have the same value. Even the soot contained in producer gas does not have the necessary fineness, and therefore does not have the same effect as carbon generated in an elemental state.

In observations made on the heat-radiation emissivity of exhaust gases in an open-hearth furnace it was also noticed that vapors of slag and iron and manganese oxides, lime dust, etc., powerfully affect the radiation emissivity of a flame.

According to its content in carbon and vapors of metallic oxides and slags, the flame in respect to gas radiation may pass through all the stages from pure gas radiation to radiation from soot in the state of the finest subdivision.

The conclusions bear out the old predictions as to the value of the so-called "luminous" flames. The present tests have confirmed the claim that the so-called invisible flames "do not work" in an open-hearth bath, but that they begin to work when properly inoculated with carbon. However, these conclusions should not lead one into fallacies of heat engineering. They do not affect the ideal represented by the bunsen burner with its theoretical combustion. They do, however, give one the power to control heat transmission by supplying to the flame cheap artificial carbon in an elemental form, as, for example, by the injection of tar, and enable this to be done without materially increasing the total heat content of the flame. As a matter of fact, the heat of "materials of inoculation" should not exceed 4 to 5 per cent of the total heat.

The foregoing information is expected to be productive of new viewpoints in the matter of the design of gas chambers in regenerative furnaces of all kinds, and in the matter of brickwork and the proportioning of these chambers. It also affords an explanation of the fact (first pointed out by Hudler in 1912) that with the same amount of heat in a boiler furnace the temperature of the flue gases is the lower the higher the initial temperature, and vice versa. At first this seems paradoxical, but in the course of the present investigation it has been found that the only gases lacking in power to radiate heat are oxygen and nitrogen. As the proportion of these gases increases the initial temperature falls off and the heat transmission does likewise because of the reduction in concentration of radiating gases. This explains the higher flue-gas temperature; on the other hand, at the maximum concentration of gases and zero excess of air, the heat transmission reaches its peak value and the best operation of the furnace is secured. This constitutes a strong argument for the proper installation and supervision of furnaces of any kind. (Dr. of Engrg. Lent, Duisburg-Ruhrort, in *Die Wärme*, vol. 29, no. 9, Feb. 26, 1926, pp. 145–149, 5 figs., *egA*)

Short Abstracts of the Month

AERONAUTICS

The Stinson Detroiter Cabin Plane

A commercial-type airplane of interest because it makes use of wheel brakes. According to a statement made by the designer, Eddie Stinson, it is possible in this plane to make a landing with the brakes set and wheels locked. Ordinarily when the field is covered with snow there is a tendency for the wheels to skid. It is expected that this plane will stop in an unusually short distance by application of the brakes, which permit making an ordinay stop within 100 ft.

The wheel brakes perform other functions besides that of shortening the landing run of the machine. When commencing a flight all the pilot has to do is to seat himself in the plane and set the starting switch. Putting the brakes on will prevent the machine from bounding forward while the engine is being warmed up, and completely dispenses with the necessity for chock blocks. The individual brakes on each wheel are worked in conjunction with the rudder bar. If the pilot desires to apply the brakes to both wheels, he presses down on both pedals. If he wishes to apply brakes on one wheel, he merely presses one foot pedal. By having the brake pedals arranged on the rudder bar it is possible to operate the rudder and brakes together, the one assisting the other and rendering ground maneuvering easy and convenient. Incidentally—probably for the first time—automobile chains were fitted to the wheels of the undercarriage of the machine for landing on snow-covered ground. (*Aviation*, vol. 20, no. 13, Mar. 29, 1926, pp. 448–449, 6 figs., *d*)

ENGINEERING MATERIALS (See also Metallurgy: Phosphorus in Wrought Iron Made by Different Puddling Processes: Welding: Stelliting)

Fireclay Refractories

Fireclay brick should be so fired in manufacture that the stable constituents mullite and tridymite are formed. Until recently it was generally accepted that sillimanite was the stable compound at high temperatures. In 1924 Bowen and Greig showed, however, that mullite was the stable high-temperature compound. These workers stated that if the one-one mixture or compound

were heated to 1545 deg. cent. (2813 deg. fahr.) it broke down to mullite and silica. The most refractory mixture was the three-one, which at 1810 deg. cent. (3290 deg. fahr.) decomposed to corundum and liquid. This means that for all fireclay compositions 1545 deg. cent. (2813 deg. fahr.) is the critical temperature (without consideration of the harmful effect of fluxes), for at this point liquid is formed. If alumina is added so that the clay contains 72 per cent or more of Al_2O_3, the material will consist of corundum and mullite up to 1810 deg. cent. (3290 deg. fahr.).

Refractories rich in mullite are very resistant to attack by mullite silicates such as basic slags and glasses. Natural sillimanite is now being successfully used as the source of high-grade mullite refractories. Each refractory problem must be considered on its own merits. In general, if we wish material to resist deformation at elevated temperatures, a fine, close texture must be used. On the other hand, if violent temperature fluctuations are the main cause of the trouble, a coarse-textured refractory will give the most satisfaction. In all cases the total amount of impurities should be low. Iron compounds are undesirable if the material is in contact with a molten silicate or if it is subjected to an atmosphere rich in carbon monoxide, hydrogen, or steam.

X-ray examination of refractories is proving extremely useful. In practice the best results are obtained by exposing a polished surface of the material to a beam of X-rays. A photographic film is exposed to the reflected rays, and subsequent development reveals the pattern which is the sum of the crystalline phases present in the sample. By finding the patterns of known compounds, it is comparatively easy to identify the constituents present, say, in a brock or slag. A number of X-ray deflection patterns illustrating constitutional changes in silicate bodies are given in the original article. (J. F. Hyslop in *The Royal Technical College Metallurgical Club Journal*, no. 5, 1926, pp. 31–32 and a plate of drawings, *g*)

FUELS AND FIRING (See also Internal-Combustion Engineering: Anti-Knock Materials; Dopes and Detonation)

An Air Furnace with an Underfeed Stoker

IN THE new foundry of the Berryhill Malleable Iron Co., Evansville, Ind., there has been installed a melting furnace with an underfeed stoker. The stoker automatically feeds the furnace with coal by means of rams operated by air cylinders which are actuated by Cole automatic valves. The valves are operated by a $^1/_2$-hp. motor attached to the valve stand. The stoker also has two adjustment devices which regulate the speed at which the main and lateral feeds operate, thus controlling the amount of coal burned. The laterals work the coal bed back toward the rear at the furnace end walls, the ashes being deposited on a "dead" plate and dumped into an ashpit.

The air furnace, which has a capacity of 15 tons, is of the reverberatory type, and has steel buckstays made of 4-in. by 6-in. angles bolted together with 3-in. spreaders. The buckstays are set on 4-ft. centers, and the side plates are made in narrow sections, having lips extending around the angles to which they are clamped. Serving the furnace is a steel-shell stack, 4 ft. in inside diameter, which extends down to the floor, not being supported on a brick base as is customary in most foundries. The furnace is charged with iron by a 2-ton electric crane, which handles buckets in which the charges have been made up.

Differing from the ordinary hand-fired furnace, the melting furnace at the Berryhill plant does not require any top blast. Instead, the flame is deflected to the bath by an angle in the roof which holds the flame low in the furnace. With the top blast removed there is less oxidation, thus insuring a more uniform product, it is said, and making it possible to use a smaller percentage of pig iron with the sprues and scrap.

Coal for the stoker is dumped into a hopper by a laborer, who wheels it from the bins nearby. Each wheelbarrow en route passes over a scale and the weights of the coal are recorded for coal-ratio determination and accounting purposes. (Burnham Finney, Resident Editor of *The Iron Age*, Cincinnati, in *The Iron Age*, vol. 117, no. 16, Apr. 22, 1926, pp. 1119–1123, illustrated, *d*)

The Staveley System of Low-Temperature Carbonization

A CONSIDERABLE amount of large-scale experimental work on low-temperature carbonization has been carried out since; 1916 by the Staveley Iron and Coal Co., Ltd. of Chesterfield. These investigations were devoted particularly to the section of low-temperature carbonization which is of special interest to the mining industries, i.e., that of the maximum oil production from, and the general utilization of, all kinds of refuse colliery material. The work carried out at Staveley can be conveniently divided into four sections: (1) The use of an externally heated pot-shaped cast-iron retort having an internal agitator, with the charge at a temperature of about 930 deg. fahr. (500 deg. cent.), operated under a high vacuum, with which the name of W. F. Winmill is associated. (2) A special method of working retorts and condensing plant under a considerable pressure, primarily the idea of K. B. Quinan, late of the Ministry of Munitions. (3) The Main process (Markham retort), which was commenced in the early part of 1921, and employs an intermittent vertical internally heated retort, in which the charge is lighted at the top; a carefully regulated supply of air and steam is then passed in at this point and down through the charge. A zone of combustion then travels steadily toward the bottom, driving off all the gases and vapors in front of it, which are withdrawn from below along with the eight products of combustion. (4) The use of the heated inert gases, including the exhaust of a large 7150-hp. Cockerill gas engine as a heating medium in a retort as in method (3), except that the gases replace the steam and air and carbonize by the sensible heat.

The original article describes the Winmill-retort process already described by the inventor in the *Journal of the Society of Chemical Industry*, 1917, vol. 34. The Quinan and Markham processes are also described. Dozens of large-scale experiments were performed with different fuels under greatly varying conditions and air. From a coal containing 27 per cent volatile matter and 33.5 per cent ash, the yield is 21 gal. of dry crude oils, 0.75 gal. of light oils scrubbed from the gas, and 16.8 lb. of sulphate of ammonia as liquor. This coal required from 40,000 to 60,000 cu. ft. of air per ton, and very roughly 200 to 300 lb. of steam at 60 lb. pressure.

From a product like bastard shale the residual gas is of no value. In general, refuse canneloid material gives 20 to 30 gal. of crude oil per ton, while in the case of any admixture of true cannels the average figure is about 40 gal. of oil and 35 lb. of sulphate of ammonia.

With good-grade bituminous coal the following are typical figures representing a number of different runs, the coal used having the following analysis: Fixed carbon, 54.5 per cent; volatile matter, 32.5 per cent; ash, 7.2 per cent; moisture, 5.8 per cent. B.t.u. per pound, 13,750. Sulphur, 1.5 per cent; nitrogen, 1.1 to 1.3 per cent.

Great interest attaches to the experiments now in progress for the use of the large gas-engine exhaust as the heating medium in a retort of this character. The gas engine at the Devonshire Works, Staveley, is of 7150 b.hp. and started up on June 27, 1925.

In the carbonization experiments the retort used is of steel plate 10 ft. 10 in. high and $2^1/_2$ ft. in diameter, with a charge of 20 cwt. A part of the hot gas-engine exhaust—at about 1110 deg. fahr. (595 deg. cent.)—is taken off from the large supply pipe that goes to the waste-heat boilers, and passes down through the charge in the ordinary way, the gases and vapors evolved by the carbonization mixed with the exhaust passing out at the bottom to the condensing plant. The circuit includes a mechanical exhauster in the ordinary way, as well as vertical pipe condensers, cooling coils with fin attachments in the top half, gas meter, and vertical wash-oil scrubbers. No details of this work are as yet available, but a number of runs have been carried out and it is certainly a novel idea to use internal-combustion-engine exhausts for carbonization. (David Brownlie (Mem. A.S.M.E.) in a paper before the Midland Counties Institution of Engineers; abstracted through *Iron and Coal Trades Review*, vol. 109, no. 3031, Apr. 2, 1926, pp. 576–577, 2 figs., *d*)

Peat Gas as Fuel in an Italian Plant

IN VIEW of the high cost of coal in Italy, attention has within the past few years been devoted to methods of utilizing the deposits

of peat which abound in certain parts of that country for the generation of electric power. One of the most recent and important installations of this kind is that which has been established at Torre del Lago near Lucques by the Societa Torbiere d'Italia. The peat is treated in Mond-type gas producers, the gas being utilized for the firing of the boilers which supply steam for the running of the turbo-generators.

Peat is obtained from a deposit on the banks of Lake Massaciuccoli, where there are several seams of a thickness of about 14 to 15 ft.; it is estimated that no fewer than 12,000,000 tons are available. The deposit is worked by means of grab cranes; the buckets, which have a capacity of 53 cu. ft., make about 60 grabs per hour and for the most part work under water, the peat being for a great portion of the year submerged. The peat when extracted has a dark brown color, is of fibrous character, and contains as much as 85 per cent moisture. It is first allowed to dry in the open air until the humidity falls to about 35 per cent, under which condition a cubic meter (35.31 cu. ft.) weighs 880 lb., the carbon content being 16.42 per cent, that of volatile matter 32 per cent, and the heating value, 2100 calories.

When air-dried, the peat is loaded into barges and transported to the gasification plant, about $1^1/_4$ miles away, where it is transhipped by grab cranes into hoppers which feed the gas producers. At present six of these are in operation, but a further two units are being added. The producers have a diameter of 18 ft. and a height of $25^1/_2$ ft.; each is capable of gasifying 4 tons of peat per hour under normal conditions and 4 tons per hour when accelerated. The peat is fed to the producers at the top and pases through three zones, the temperatures in the respective zones being approximately 150 deg., 450 deg., and 800 deg. cent. At the base a blast of air with 80 per cent moisture is injected into the producer. The resulting gas which leaves the producer at a temperature of about 90 deg. cent. has an average composition of CO_2, 8.04 per cent; H, 17.12 per cent; CH_4, 5.88 per cent; CO, 20.80 per cent; O, 0.02 per cent; and N, 48.16 per cent.

When the whole eight units are in operation, the battery of gas producers is expected to yield about 2,412,000 cu. ft. of gas per hour under normal conditions and about 1,118,000 cu. ft. per hour when accelerated to meet peak-load demands. Before its utilization for boiler-firing purposes the gas is heated for the separation of its utilizable chemical products. It is first passed through a Glover tower 16 ft. 4 in. in diameter and 49 ft. in height, in which the ammonia content is deposited in the form of sulphate of ammonia, the yield being given as 110 lb. per ton of anhydrous peat. From the Glover tower the gas passes to a washing tower 16 ft. 4 in. in diameter and $52^1/_4$ ft. in height, filled, like the Glover tower, with sandstone rings, and on which a fine rain of water falls. The water is collected at the base of the washer, from which it is conveyed to another tower 11 ft. 9 in. diameter and $52^1/_2$ ft. high, where it is utilized to heat and moisten the primary air for the gas producer.

On emerging from the washing tower the gas, which is then at a temperature of about 70 deg. cent., is directed to a battery of sheet-iron condensers 32 ft. high, provided with cooling coils in which the water and tar in the gas are condensed, two large tanks serving for the storage of the tar and tar water. The gas, the temperature of which is now about 40 deg. cent., next passes to a battery of scrubbers, where it is freed of any remaining traces of water, and is then piped direct to the boilers, no gas holder being employed as a measure of economy in installation cost; a small gasometrical bell is, however, provided as the outlet from the condensers, this serving as a sort of valve controlling the primary air inlets to the gas producers.

The plant in which the gas is utilized comprises eight Tosi vertical-tube boilers. The electricity generating plant will eventually consist of three sets of 5000-kw. turbo-generators producing $16^2/_3$-cycle alternating current at 4000 volts at 1000 r.p.m. At present two generating sets are in operation, the current output being installed for traction purposes on the Spezzia-Pisa-Leghorn and Pisa-Florence electric railways. The boilers are normally fired by peat gas, but provision has been made so that tar or even pulverized peat may be utilized. It is estimated that when fully completed the Torre del Lago installation will be able to supply current to the extent of 30,000,000 kw-hr. and produce 5000 tons of tar and an equal quantity of sulphate of ammonia per year. (Chas. J. Webb in *Power Plant Engineering*, vol. 30, no. 9, May 1, 1926, p. 531, *d*)

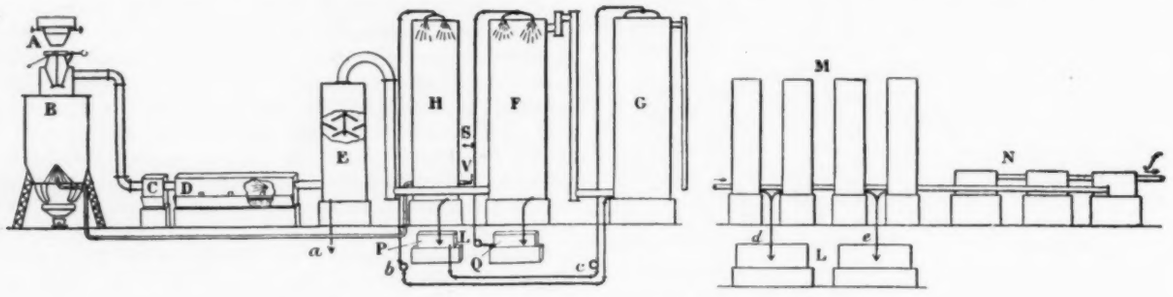


FIG. 1 DIAGRAM OF ITALIAN PEAT-GASIFICATION PLANT

A, Peat truck; *B*, Gas producer; *C*, Hydraulic valve; *D*, Gas washer; *E*, Dust remover; *F*, Glover tower; *H*, Primary air heater; *L*, Tar and tar-water tanks; *M*, Tar condensers; *N*, Scrubbers; *P*, *Q*, Tanks; *S*, Sulphate suction pipe; *V*, Primary air pipe; *A*, Dust-removal connection; *B*, Washing-tank connection; *C*, Washing-water pumps; *D*, *E*, Tar and tar-water pipes; *F*, Pipe conveying gas to boilers

HYDRAULIC ENGINEERING (See Special Machinery: A Speed Governor for Small Hydraulic Machinery)

INTERNAL-COMBUSTION ENGINEERING

Anti-Knock Materials

TO STUDY the relative effectiveness of anti-knock compounds, a one-cylinder 3/4-kw. Delco light motor was employed. The set-up, including the bouncing-pin apparatus, was similar to that described by Midgley and Boyd, and their method of comparison was in general followed.

The anti-knock effectiveness of any compound is expressed below by an "anti-knock coefficient." It is the inverse ratio of the number of mols of a given compound required to give the same degree of suppression of detonation as does one mol of lead tetraethyl in a constant volume of the same basic fuel mixture. Lead tetraethyl, the most effective of known anti-knock compounds, is given an anti-knock coefficient of 100, and all other values are referred to it.

For example, 0.0033 mol of lead tetraethyl and 0.0051 mol of lead tri-*p*-xylyl per liter of fuel were equivalent in their effect in suppressing the knock; hence the anti-knock coefficient of lead tri-*p*-xylyl is

$$\frac{Pb(Et)_4}{Pb(Xy)_3} = \frac{0.0033}{0.0051} \times 100 = 64.7$$

This means that the latter compound is molecularly but 64.7 per cent as effective as lead tetraethyl, the standard. This method of comparison serves as a convenient and natural means whereby a number of widely varying results may be compared.

It has been shown that the anti-knock property is exhibited by four elements not included in previous lists. Nickel as the carbonyl was found to have an anti-knock coefficient of 30; bismuth in its trialkyl derivatives possesses a coefficient of 18.2 to 20.2; cad-

mium in its alkyl compounds and titanium as the tetrachloride were also found to function, but in a less marked degree. New data are also presented relative to some additional compounds of metal already known to possess anti-knock properties.

It has been supposed that the state of valence of the anti-knock element was essential in determining which of its compounds should function. Thus, tetravalent lead in its alkyls was known to function as an anti-knock, while in its divalent form, as in lead acetate, it was known not to function. That such a generalization, based on valence alone, is not valid became apparent in this work when certain compounds of tetravalent lead, as lead tetrastearate, lead diphenyl di-acetate, etc., were found to be without effect, while certain compounds of divalent lead, as lead thioacetate, were shown to give effective suppression.

Very little appears in the literature relative to the chemical nature of detonation in engines. The view held here is that it is a sudden disruption of the molecule, and thus depends in a large part upon the stability toward heat of the molecule itself.

If this conception of detonation is accepted, the only manner in which hydrogen could detonate would be

$$H_2 \rightleftarrows H + H.$$

The fact that the reports with hydrogen in the tube, although very loud, were lacking in the sharp characteristic "crack" accompanying the detonation of acetylene, indicates that this equation probably does not describe the reaction. The term "explosion," meaning very rapid oxidation, is therefore applied in this instance as distinguished from "detonation," meaning an almost instantaneous disruption of the molecule. Throughout this article the above meanings are attached to these terms.

If the suppression of detonation in the tube with acetylene-air mixture were strictly comparable to the knock or detonation in engines, compounds which influence the latter phenomena would be expected to affect the former in the same manner.

Such is not the case, and furthermore detonation in engines is dependent upon higher pressures and temperatures than obtained with a tube. The authors conclude, therefore, that an attempt to apply the results of observations made with the detonation tube to a study of an explanation of the suppression of the fuel knock in the motor or vice versa is justified. The authors offer a chemical theory of anti-knock materials and their action in suppressing detonation.

The very fine particles (or vapor) of the anti-knock metal are conceived as undergoing such rapid oxidation as to develop sufficient heat to raise them momentarily much above the temperature of the yet unburned gases in which they are present. There is thus created at a definite stage in the engine cycle a large number of centers, in and very close about which there is produced an abnormally high temperature. Such a condition would tend to cause a partial oxidation of the fuel rather homogeneously throughout its entire volume. The anti-knock would thus function as a kind of auxiliary ignition system, tending to start oxidation of the fuel ahead of the actual flame front in a region of hot, highly compressed gases. These gases under other conditions would be chemically unchanged until the flame front had passed through them or until their pressure and temperature had become great enough to cause their detonation.

The original paper gives a table of anti-knock compounds and a table of compounds which have been tested and found to be without effect in suppressing the knock. (Wm. Hale Charch, Edward Mack, Jr. and Cecil E. Boord, Chemical Laboratory, Ohio State University, Columbus, Ohio, in *Industrial and Engineering Chemistry*, vol. 18, no. 4, Apr., 1926, pp. 334–340, 7 figs., *teA*)

Peugeot Heavy-Oil Engine for Motor Cars

THE Peugeot Automobile Co. of Paris is now making trucks and cars equipped with an injection-type heavy-oil engine. The engine, built under Tartrais patents, is of the two-cycle type with crank throws at 180 deg. One such engine was put through a 50-hr. bench test in six periods and is said to have shown very satisfactory results. This engine was a twin-cylinder 4.7 by 5.9-in., and maintained an average output of 41 hp. at 1300 r.p.m. and 53 hp. at 1450 r.p.m. The fuel consumption averaged 0.451 lb. per hp-hr. of a gas oil of a specific gravity of 0.87.

The particular features of the Peugeot engine are the special shape of the cylinder head, the fuel-injecting pump, and the use of an air pump for scavenging and for charging the cylinders. As will be seen from Fig. 2, there is a bottle neck between the cylinder barrel and the cylinder head, while the aluminum-alloy piston (13 per cent copper) has a very thick domed head designed to drive the air into the combustion chamber. Originally the head was maintained at the highest possible temperature, there being no cooling water, and special material had to be used to withstand

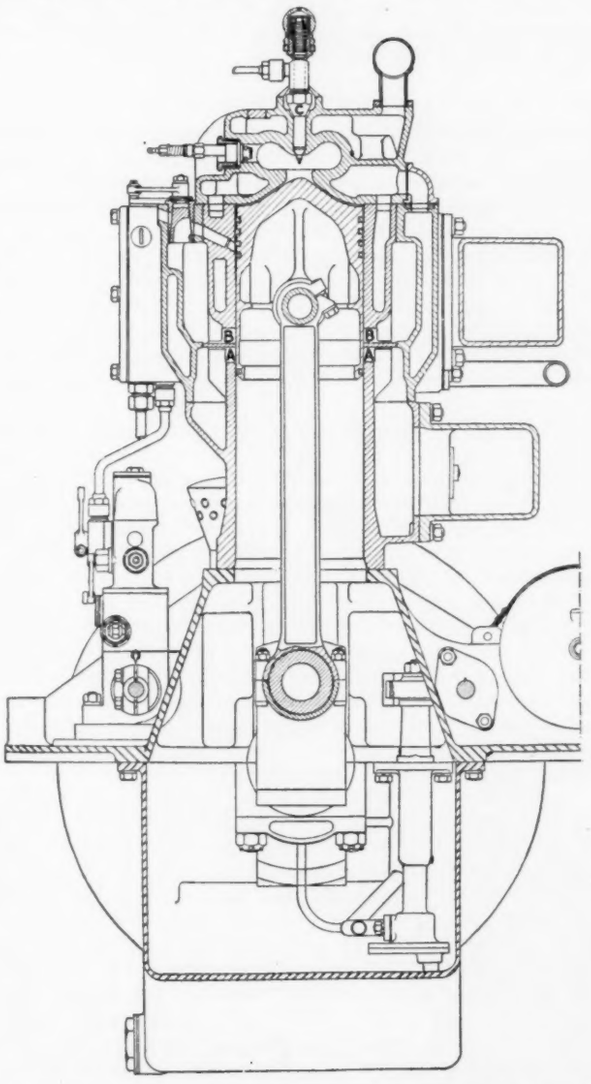


FIG. 2 CROSS-SECTION THROUGH CYLINDER OF PEUGEOT HEAVY-OIL ENGINE

the high temperature. As it is now produced, the head is a normal cast-iron type, water-cooled, and held to the cylinders in the usual way by means of studs.

An air pump driven off the front end of the crankshaft delivers air to the cylinder through the lower inlet ports *A*, thus tending to scavenge the spent gases through the upper ports *B*. By reason of the bottle neck and the shape of the piston, the air is driven into the combustion chamber at a considerable velocity and high turbulence is created.

Direct injection of the fuel is obtained from a plunger-type pump and an injector *C* mounted centrally in the cylinder head. The liquid fuel coming in contact with the air projected into the combustion chamber at high velocity, is completely broken up and a homogeneous mixture is obtained. With a compression ratio of 12, the heat developed is sufficient to fire the charge, particularly when the combustion chamber has reached a normal working temperature.

For starting up from cold, a special plug and electric current are

made use of. The plug consists principally of a small coil of platinum wire, through which the current of a small battery can be switched, thus heating the wire and causing it to fire the charge at the end of the compression stroke. After a few revolutions of the engine the current is switched off. Variation of engine speed is obtained by controlling the timing of the pump and the length of the stroke of the plungers.

Weighing 10 lb. per hp., the Peugeot engine compares favorably in the matter of flexibility with the normal gasoline engine, and, in addition to using cheaper fuel, is particularly economical when running under light loads. (*Automotive Industries*, vol. 54, no. 15, Apr. 15, 1926, pp. 662–664, 6 figs., *d*)

Dopes and Detonation

Data of an investigation made by the Air Ministry Laboratory, Imperial College of Science and Technology, London. Since the war many substances have been added to gasoline with the idea of suppressing detonation and permitting a higher compression ratio to be usefully employed. The most remarkable of these dopes is tetraethyl of lead, or lead ethide, discovered by Midgley and Boyd. Trials made at the Air Ministry Laboratory have shown that the addition of only a quarter of one per cent by volume (or less than half a fluid ounce per gallon of fuel) to any of the usual brands of gasoline enables the compression ratio to be raised nearly 40 per cent, with an increase of power of 14 per cent on the same fuel consumption.

The chief objections to the use of lead ethide as a dope appear to be that it is extremely poisonous and gives rise to lead deposits in the engine which may produce deleterious effects, such as sticking up valves, fouling spark plugs, and interfering with piston lubrication. These latter defects have been greatly mitigated by adding an equivalent quantity of ethylene dibromide, which renders the deposits much less harmful. The patentees recommend, however, that the mixed dope, called "ethyl fluid," should not be used in a greater proportion than 5 cc. per gallon, each 5 cc. containing 3 cc. of lead ethide, which, according to the A.M.L. tests, would permit an increase of compression ratio of about 10 per cent. The importance of this limitation has recently been confirmed by an endurance test of 100 hr. on a Napier Lion engine of 450 hp. at the Royal Aircraft Establishment. During the test the engine was throttled from 2150 revolutions at full power to 2000 revolutions, i.e., to about 80 per cent of full power. Shell Aviation spirit was used for the first 50 hr. with 5 cc. per gal. of the normal ethyl fluid. For the second 50 hr. B. P. Aviation spirit was employed with 5.5 cc. per gal. of ethyl fluid, containing a larger proportion—namely, 2.5 cc. of ethylene dibromide—the content of lead ethide being 3 cc. in both cases.

After the 100-hr. test the general lubrication of the engine was satisfactory, with the exception of the cylinders. The excess bromide used during the second half of the test appeared to have resulted in a deposit of iron oxide on the cylinder walls. After 50 hr. the spark plugs showed heavy deposits of lead salts and high leakage of gas through the mica. After 100 hr. these defects were intensified. All plugs showed signs of having been severely overheated, and the deposits of salts formed an easy flash-over path. Three cases of punctured mica were noted, which would render the plugs useless in an engine. For the power tests, after 50 hr. it was found necessary to fit a comparatively new set of sparking plugs, the plugs used on the endurance test being unfit for full-throttle running. After a further 50-hr. endurance test, a new set of plugs again proved to be necessary for full-throttle running. The performance of ethyl fluid after 100 hr. was little inferior to that obtained after 50 hr., but on turning over to 20 per cent benzol mixture the engine commenced detonating and overheating, and it was considered inadvisable to take a power curve under these conditions.

It is said that engines of the ill-fated airship *Shenandoah*, with a compression ratio of 6:1, used a mixture of Aviation spirit with 10 cc. of ethyl fluid per gal., which would probably lead to similar troubles at full power.

Other dopes, such as nickel carbonyl, possessing a high order of effectiveness, have been discovered, but all of these are less effective than lead ethide, and are liable to similar objections in a greater degree in proportion as larger quantities are required.

Section 1 of the paper presents a general theory and review of previous work by Prof. H. L. Callendar. This begins with the discussion of ignition temperature of fuels in the presence of air or oxygen. In the opinion of the author there is evidently a close relation between lowness of ignition temperature and tendency to detonate, but other factors such as the effect of pressure have to be considered in attempting to frame a theory.

The author observes that a paper by Tizard and Pye (*Phil. Mag.*, July, 1922, p. 79), on Ignition by Compression, explains more fully how the observed ignition temperature depends on the rate of heat generation and the rate of heat loss, and shows how the lower limit of ignition temperature may be deduced on simple hypotheses from the observed delay in ignition. It was found that the ignition temperature was raised by turbulence produced by a fan. The observation of the rates of heat loss with and without the fan, and of the minimum mean temperatures sufficient for ignition, afforded a means of estimating the rates of heat generation and deducing the temperature coefficient of the reaction velocity. The observers point out, however, that the maximum temperature in the non-turbulent mixture must exceed the mean temperature which they adopt in their calculations, but must fall short of that calculated by Dixon's method. By way of compromise they propose taking the mean of the two as the true value of the ignition temperature at this stage of the investigation. (Beginning of a serial article by Prof. H. L. Callendar, assisted by Capt. R. O. Kinn and Flight Lt., C. J. Sims, in *Engineering*, vol. 121, no. 3145, Apr. 9, 1926, pp. 475–476, *teA*. Further abstracts may appear in later issues.)

MACHINE PARTS AND DESIGN

Capacity of Belts under Operating Conditions

Data of tests conducted by the Leather Belting Exchange Foundation to compare the power-transmitting characteristics of belts operated horizontally, vertically, and at various angles with the horizontal. The tests were made with 1.5, 2 and 3 per cent slip at each tension for each belt. At the medium tension (75 lb.) with the grain sides of the two belts to the pulley the horizontal drive transmitted an average of 14.6 per cent more power than the vertical drive (at 3 per cent slip); in the flesh-side comparison the difference was 6.3 per cent. With the medium tension of 50 lb. the horizontal drive with the grain side to the pulley gave an average of 28 per cent more power, and 16 per cent with the flesh side to the pulley. The conclusion drawn is that a leather belt for a vertical drive (test center distance, 7 ft. 6 in.) should be about 12 per cent wider than for a corresponding horizontal drive. The difference at other center distances is given in a table in the original article.

The problem of the center distance is of considerable importance because the transmission capacity of a vertical belt does not increase with the center distance as does that of a horizontal belt. The operation of a vertical belt is the same as that of a horizontal belt in that as the load increases the belting material under tension on the tight side is worked over to the loose side, which reduces the tension on this side. However, the loose side of the horizontal belt can take care of additional length by sagging without much reduction of the loose-side tension, while the loose side of a vertical drive must take care of it by shortening up an amount equal to the additional length from the tight side.

A point is soon reached with the vertical belt when any further shortening of the loose side would result in zero tension on this side, and further increase in load or tension would cause the belt to fall away from the lower pulley. This is the absolute theoretical limit of transmission for any vertical drive. Practically, when the slack-side tension is reduced to a certain value the belt slips badly, and this is the actual limit of transmission. It is obvious that, since the horizontal belt can compensate for the extra length by sagging on the loose side while the vertical belt cannot, the horizontal belt ought to transmit more power.

From the above analysis it can be readily seen that the capacity of a vertical drive depends on its ability to shorten up on the loose side. If the center distance is doubled, then there will be twice as much extra length passing over the loose side for any given load, but there will also be twice as much shortening of the loose side, so the slack-side tension will remain the same. It follows, there-

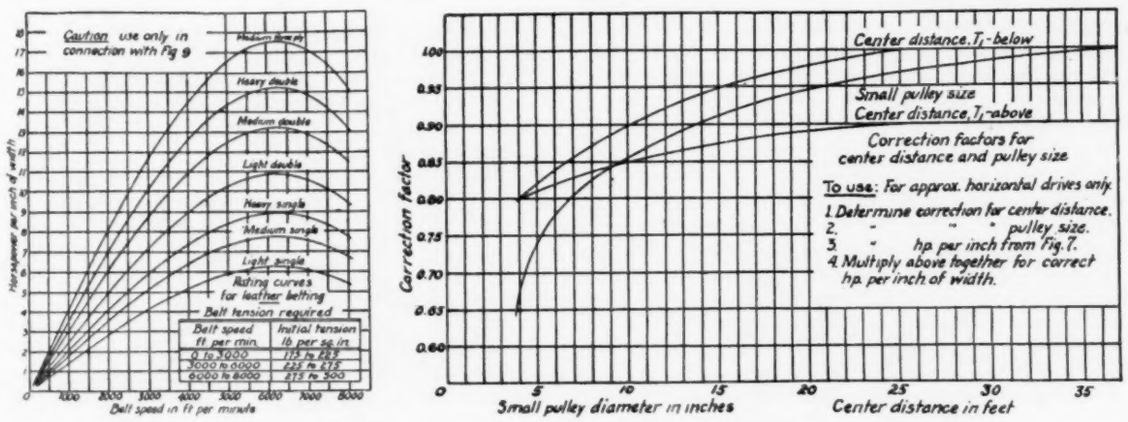
fore, that the power transmission of a vertical belt is independent of center distance, except for the effect of the additional weight of a longer belt, which is practically negligible.

As the horizontal-belt capacity increases with the center distance, while the vertical-belt capacity does not, there will be a greater percentage difference between the power transmission of the two belts at long center distances than at short ones.

The vertical belt is more sensitive to tension changes than the horizontal belt. Attention is called to the following recommendations.

1 For vertical drives, and for angle drives between the vertical and 45 deg. with the *tight side above*, use a correction factor of 0.765 multiplied by the correction factor for pulley size from Fig. 4. The product of these two factors should then be multiplied by the horsepower ratings from Fig. 3 to obtain the corrected horsepower per inch of width. No correction factor is needed for center distance.

2 For angle drives with the *tight side below* between the vertical and 67½ deg., use the method given above under (1).


Caution use only in connection with Fig 9
Medium double
Heavy double
Medium double
Light double
Heavy single
Medium single
Light single
Rating curves for leather belting
Belt tension required
Belt speed ft per min
Initial tension lb per sq in
0 to 3000
175 to 225
3000 to 6000
225 to 275
6000 to 8000
275 to 300
Horsepower per inch of width
Belt speed in ft per minute
Correction factor
Center distance, T, below
Small pulley size
Center distance, T, above
Correction factors for center distance and pulley size
To use: For approx. horizontal drives only
1 Determine correction for center distance.
2 " " " pulley size.
3 " hp per inch from Fig. 7.
4 Multiply above together for correct hp per inch of width.
Small pulley diameter in inches
Center distance in feet

FIGS. 3 AND 4 CORRECTION FACTORS FOR DETERMINING BELTING ANALYSIS
(Extensive instructions as to the use of these curves are to be found in the original article.)

3 For angle drives with the *tight side below* between 67½ deg. and 45 deg., use a constant correction factor of 0.815 instead of 0.765 and proceed as directed under (1). No correction factor for center distance is needed as the figure 0.815 takes its place.

4 For angle drives between 45 deg. and the horizontal, with the tight side above or below, use the method of design as explained at length in the caption with Figs. 3 and 4. (R. F. Jones, Research Engr., The Leather Belting Exchange Foundation, Cornell University, Ithaca, N. Y., in *Industrial Engineer*, vol. 85, no. 4, Apr., 1926, pp. 165–170, 9 figs., *ep*)

MACHINE SHOP

Flywheel Manufacture at Nash Plant

DESCRIPTION of the methods used at the Milwaukee, Wis., plant of the Nash Motors Co. The flywheels are made on a group of four "simplimatic" machines built by the Gisholt Machine Co. of Madison, Wis. Each performs a complete operation automatically. Four operations are used to complete the wheel, and each machine performs one of these operations. After the wheel has been chucked and the machine started, the latter completes the operation, returns the cutting tools by quick traverse to the starting position, and stops the spindle automatically. The rate of feed is regulated so that each tool slide is given the feed best suited to the kind and length of cut it has to perform. The machine has to be built in a rugged manner. In the first operation, for example, eight surfaces are machined simultaneously by eight tools carried in four tool holders mounted on two tool slides. One man attends two machines. He checks the castings and removes the finished work. He also sharpens his tools and resets them. The time required to complete each operation is 4 min. Mechanical training and experience on the part of the operator are unnecessary. (Frank Edwards in *The Automotive Manufacturer*, vol. 67, no. 12, Mar., 1926, pp. 17–18, 2 figs., *d*)

MARINE ENGINEERING

High-Pressure Water-Tube Boilers for Marine Purposes

THIS paper contains a general discussion of the application of high-pressure boilers for marine purposes. In some ways this is simpler than for land purposes, while in other respects special care has to be taken, for example, to prevent leakage of salt water into the system from the condenser plant.

Two high-pressure coal-fired boilers of the Yarrow type are to be installed on a passenger vessel now being built by Wm. Denny & Bros. for Turbine Steamers, Ltd. The design of the boiler has been passed by the British Board of Trade.

Each boiler, a general arrangement of which is shown in Fig. 5, has a total heating surface of 3420 sq. ft., of which the superheating surface is 870 sq. ft.; in addition, there are 2200 sq. ft. of air-heating surface for preheating the air prior to its admission to the closed ashpit. The safety valves are set to 575 lb. pressure, and the final temperature will be from 700 deg. fahr. to 750 deg. fahr. The test pressure is 913 lb. The design generally, while not unlike that used in the Navy, has been based on mercantile practice, and most closely follows the design of the Yarrow land-type boiler now in use at several electric power stations.

As will be seen from Fig. 5, the boiler consists of a forged steam drum connected to the three forged water drums by means of straight tubes expanded and bell-mouthed in accordance with the usual practice. Between the two water drums on the right-hand side is a superheater which consists of a forged drum with a number of U-tubes and which is placed between the two generating elements. The gases all pass up one side of the boiler and through the air heater situated above the boiler and to the funnel. The reason for adopting a single-flow type of boiler, where all the gases pass through one side, is because this design makes in this particular case a somewhat better arrangement in the ship than the double-flow type where the gases pass equally through each side. The generating element in the left-hand side of the boiler absorbs a considerable portion of the heat from the furnace by direct radiation, and it will be noted that the proportion of the total surface of the boiler subject to direct radiation, is considerable, which is an important feature in modern water-tube boiler design, not only increasing the output and efficiency of the unit, but also providing a large amount of comparatively cool surface adjacent to the combustion chamber, which lengthens the life of the brickwork.

The admission of air for combustion is arranged in the following way: The cool air in the stokehold enters an opening between the inner and outer casings at the front of the boiler about 6 ft. up from the firing floor, passes up the double casing through the air heater, down the double casing at the back of the boiler into the closed ashpit, and so through the grate bars. The efficiency of the unit is naturally increased by the air heater, which extracts heat from the flue gases, and in addition the air in its passage to the combustion chamber as above described takes up a certain amount of heat which would otherwise be lost due to radiation, and incidentally keeps the stokehold cool. Also the circulation of air in close

proximity to the furnace lining helps to keep the brickwork at a temperature which insures low cost of upkeep.

For controlling the supply of steam—especially as, unlike an oil-burning boiler, the supply of fuel cannot be quickly cut off—various means of regulation have been provided. It will be seen that a damper is fitted in the uptake at the side of the top of the air heater. When this damper is in its horizontal position the air passes through the air heater to the combustion chamber. When, however, the damper is brought to a vertical position the air from the fan passes straight up to the funnel, thereby short-circuiting the air heater and entirely stopping the supply of air for combustion. This arrangement would be used when the engine is stopped suddenly, e.g., when the vessel stops at a pier. Provision is also made for controlling the speed of the forced-draft fan, thereby limiting the amount of air for combustion. A still further control is to bypass the steam direct from the boiler to the condenser by the silent blow-off.

In preparing the design of a high-pressure boiler it is advisable to reduce the number of riveted and bolted joints to a minimum, and how this has been accomplished in the present case will be seen from the fact that the steam drum has no riveted joints at all, and, apart from the attachment of boiler mountings, the only bolts are those required to secure the two internal manhole doors. In the water drums and superheater drum there are no longitudinal joints, and only one circumferential riveted joint securing the front end plate

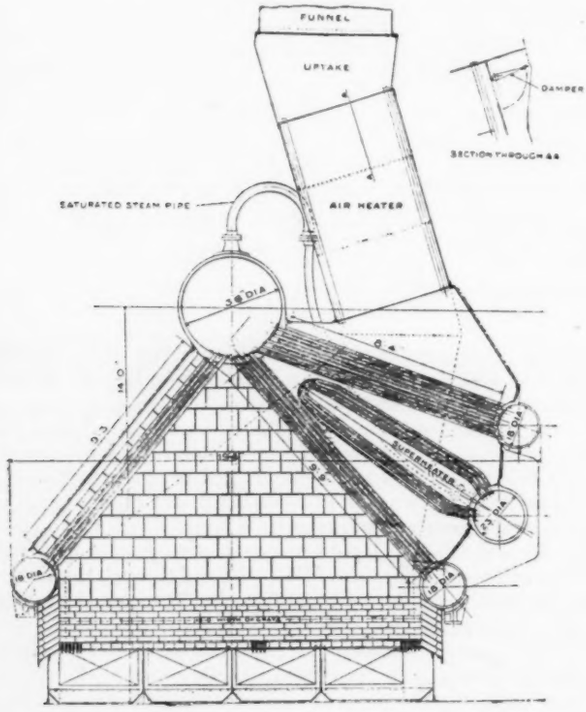


FIG. 5 YARROW HIGH-PRESSURE WATER-TUBE BOILER FOR 575 LB. PER SQ. IN. PRESSURE

in which the manhole is placed. The other end of these drums is solid.

All the drums have been manufactured by John Brown & Co., of Sheffield, and a short description of the process of manufacture may be of interest. The steel used is ordinary boiler steel of 26–30 tons, with 30 per cent elongation in 3 in. lengthwise and not less than 20 per cent elongation in 3 in. transverse. The large steam drum is made by the following method: A large octagonal ingot is forged under a hydraulic forging press to a round billet; it is then cut to a length which will give the weight necessary for the finished forging, and is carefully examined for any surface defects. The billet is then bored with a hole throughout its entire length large enough to take a mandrel for the second forging operation.

The second forging operation consists in expanding the billet to a larger diameter without increasing the length; the internal diameter after this operation is slightly less than the finished diameter of the steam drum. The expanded forging is reheated ready for the third operation, which consists in forging on a mandrel in such a manner as to increase the length without increasing the diameter. A mandrel is used of a diameter approximately that of the finished drum, and forging is continued until the required length is obtained. The thickness of the main body is now that required for the drum, plus machining allowances. The ends of the forging are left thicker to allow for the final operation, which takes place after the internal diameter of the drum is bored to the finished sizes. This last forging process consists in closing in both ends as nearly as possible to the required shape of the finished drum. The final closing in is performed on a round bar or mandrel somewhat smaller in diameter than the manholes in the end. The forging is then thoroughly annealed and sent to the machine shops, where the necessary mechanical tests are taken and the final machining carried out. The process of forging the water and superheater drums is much simpler. The boiler tubes and superheater tubes are solid-drawn, cold-finished.

The problem of boiler fittings such as safety valves, stop valves,

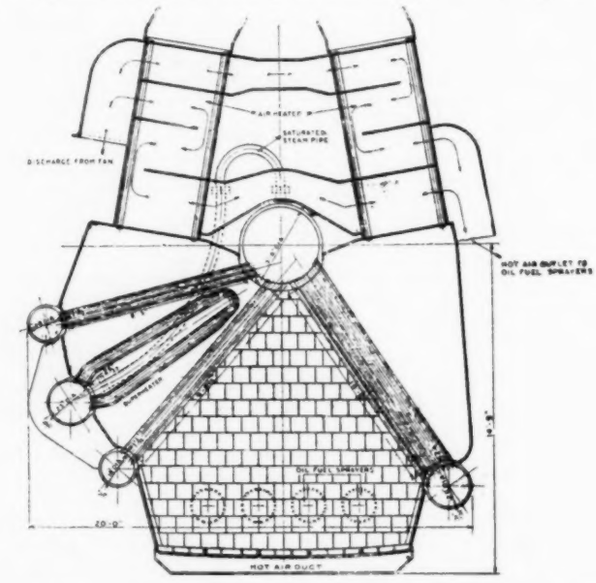


FIG. 6 YARROW WATER-TUBE BOILER FOR 1000 LB. PER SQ. IN. PRESSURE

joints, etc., is one to which much care must be devoted. The safety valves require special consideration in design and construction for high pressures and temperatures. The ordinary safety valve with its small lift is a trap for grit, etc., when the valve is blowing off. The valve shuts down on this grit, and soon indentations extend across the face and the high velocity causes grooves to be cut. The safety valves for the two boilers above referred to are of the high-lift type manufactured by Cockburns, Ltd., and either this type or the full-bore safety valve manufactured by the same firm would seem to meet adequately the problem of high pressures and temperatures. The stop valves and other fittings are of the usual design, strongly constructed and of suitable materials. The main stop valve has monel-metal spindles, valves, and seats, but other materials have been found to be equally satisfactory. The joints, as already stated, are metal to metal, and the flanges are particularly thick so as to avoid the possibility of any distortion. The feed regulators are being supplied by the Aster Engineering Company, and the water gages by Dewrance & Co.

With regard to the initial cost of a high-pressure boiler, the price of the solid drums is at present greater than built-up drums, but a number of the fittings are common to boilers whether for high or low pressures, such as furnace fittings, casings, uptakes, air heaters, brickwork, etc., so that the total increase in cost is not considerable. It is estimated that the two boilers described above with forged drums for 575 lb. pressure cost approximately 15 per cent to 20 per cent more than similar boilers having the same total heating surface, but having a boiler pressure of 250 lb. per sq. in. If, however, a comparison is made on a more correct basis—that is to say, taking into account the fact that the quality of the steam for

the 575-lb. boiler is of a higher value than in the case of a lower pressure, then the cost of the high-pressure boiler is very little more than the cost of the other. The saving due to the reduced heating surface required in the case of the high-pressure boiler nearly compensates for the additional cost of the forged drums and certain other rather more expensive fittings. The initial cost of high-pressure boilers is therefore no handicap to their introduction.

Fig. 6 shows a section of a Yarrow boiler suitable for 1000 lb. pressure, the boiler being of such a size as would produce steam for 400 s.hp. when being worked at a very moderate rating. This boiler is of the double-flow type, but it can, of course, be designed for single flow, depending upon the general layout of the boiler room. (Harold E. Yarrow in a paper read at the Spring Meeting of the Institution of Naval Architects, Mar. 26, 1926; abstracted through *Shipbuilding and Shipping Record*, vol. 27, no. 13, Apr. 1, 1926, pp. 361–363, 3 figs., *d*)

MECHANICS

Inertia Forces in the Geneva Stop and Similar Mechanisms

THE Geneva movement as used in indexing devices for automatic machinery is a particularly interesting form of mechanism as it lends itself readily to exact mathematical analysis. The equations used in this analysis are of much broader application, however, as they apply equally well to any mechanism where a crank of constant length, rotating at constant speed, drives a second arm or rotating part with variable velocity by means of a slot, the center line of which passes through the center of rotation of this member. Common examples, in addition to the Geneva stop mechanism, are the swinging-block, quick-return motion frequently found in pillar shapers, and the Whitworth quick-return mechanism where the follower makes one complete revolution for each revolution of the driving crank.

The study of these mechanisms in the past has been largely confined to velocity analysis, but the present demand for greater speed of operation is making the determination of accelerations and inertia forces a problem of prime importance.

The author derives equations for the angular velocity of the variable-velocity arm and angular acceleration of the variable-velocity arm, as well as acceleration at any desired position of the constant-velocity crank. He finds that acceleration is at a maximum at that position of the constant-velocity crank where the cosine of θ (angle made by the constant-velocity crank with the line of centers) as a certain value given in one of the equations (4). Next is given an equation for the torque on the variable-velocity arm due to the inertia of the parts.

The author proceeds next to the consideration of the forces acting on the driving shaft and expresses the opinion that in designing machinery to take care of inertia forces the knowledge of the torque on the driving of the constant-velocity shaft and the pressure on the crankpin are of great importance. Furthermore, graphical methods cannot be easily applied to the determination of these additional quantities and recourse must be had to mathematical analysis. He concedes, however, that the position of the crank when the torque on the driving shaft is at a maximum is not easily determined mathematically. It will occur very near the position at which the pin pressure is a maximum, so that the cut-and-try method can be used starting at this position and taking successive values of θ one or two degrees apart until the maximum torque has been passed.

As an illustration of the use of the equations the analysis of a turret operated by a Geneva stop mechanism is given in the original article.

The time-honored practice of proportioning machine parts so that they look strong enough to the experienced designer and of increasing the size if they fail to function properly, arose from the fact that the forces to be overcome were unknown or, at best, could only be roughly approximated. This practice is likely to lead to trouble in variable-speed mechanisms, so that it is particularly fortunate that inertia forces lend themselves readily to exact mathematical investigation. Just as the inertia forces caused by the pistons, valves, and connecting rods of automobile engines are now carefully investigated, methods of analysis such as that given above will come into greater use with increased speeds of automatic and semi-automatic machinery. (Jas. A. Hall, Professer of Mechanical Engineering, Brown University, Providence, R. I. (Mem. A.S.M.E.), in *American Machinist*, vol. 64, no. 15, Apr. 15, 1926, pp. 603–605, 5 figs., *mA*)

METALLURGY

Phosphorus in Wrought Iron Made by Different Puddling Processes

WROUGHT iron has been an important structural material for many centuries. Even today, in spite of the keen competition with steel, there are many purposes for which it is preferred to steel by engineers. The dearth of reliable published information on the properties on wrought iron from the viewpoint of modern metallurgy is surprising. An investigation recently completed by the Bureau had for its purpose the study of the effect of phosphorus, one of the ever-present impurities in wrought iron, upon the properties of the finished iron as made by different puddling processes. Recently mechanical puddling processes have been advocated and used to a considerable extent in the manufacture of wrought iron to replace the time-honored hand-puddling method, on account of the high labor costs the use of the latter necessarily entails. Very little has been published on the properties of the wrought iron made by these newer processes.

Phosphorus in wrought iron is usually regarded with some concern, since it embrittles the iron; that is, makes it "cold short." The phosphorus is contained in both the iron matrix and the slag threads to which the wrought iron owes its characteristic "fiber." Only the phosphorus in the iron matrix, however, affects the properties of the metal. Mechanical puddling appears to be more effective in reducing the phosphorus content to a lower figure than is hand puddling. Experiments were carried out on wrought iron made by each of the two methods on a "split" heat of pig iron, the two parts of the heat being refined by the two processes, hand and mechanical puddling, respectively. For certain purposes such as drill pipe, for which a "stiff" material is needed, a certain percentage of phosphorus in the iron is desirable. The amount in such a case is usually considerably higher than that in good-quality bar iron, for which the total phosphorus ought not to be much in excess of 0.15 per cent.

The investigation was not extensive enough to warrant any sweeping conclusion concerning all the merits of wrought iron made by the two processes. However, nothing was noted which would show that wrought iron made by hand puddling cannot be equaled by mechanical puddling if properly carried out. (*Technical News Bulletin of the Bureau of Standards*, no. 108, April, 1926, pp. 4–5, *e*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering: Peugeot Heavy-Oil Engine for Motor Cars)

MUNITIONS

A 16-Ton Tank

JAPAN is building a 16-ton tank which will travel at a speed of 25 m.p.h. It is to carry 13 machine guns and 2 quick-firers. It is a regular motor fort and will cost a quarter of a million yen, something like $95,000. The engineering department of the Japanese general staff has planned the new arm, which is expected to take part in the autumnal maneuvers. (J. F. Froggett in *Daily Metal Trade*, vol. 16, no. 84, Apr. 29, 1926, p. 1, *g*)

POWER-PLANT ENGINEERING (See also Fuels and Firing: Peat Gas as Fuel in an Italian Plant: Marine Engineering: High-Pressure Water-Tube Boilers for Marine Purposes)

A Power Plant with Compound and Composite Boilers

IN A steam-generating and power plant comprising high-pressure and low-pressure generators, a steam engine, a condenser, and a closed feedwater pumping system, and wherein the generators are of different type and the condenser condensate is used as feed for

the low-pressure generator which is heated by the waste flue gases from the high-pressure generator and the high-pressure generator is fed with water from the low-pressure generator, the high-pressure generator supplies steam to a turbine which is also fed from the low-pressure generator. A water-tube high-pressure boiler *a* (Fig. 7) delivers steam to a turbine *c* which exhausts into a condenser *d*. The low-pressure generator *b* which forms a feedwater reservoir also delivers steam to the turbine *c* and also steam to the heating-coil *h* of an evaporator *e*, which provides distilled make-up feed. The vapor from the evaporator *e* and condensate from the coil *h* pass into the condenser *d*, the condensate from which is pumped through a feedwater heater *x* to the boiler *b*. Water from the boiler *b* is forced by a pump *u* through a feedwater heater *w* heated by steam led from the turbine into the boiler *a*. A reverse feed tank *n* is connected to the condenser *d*. The heater *x* may be heated by the exhaust from the pump *u* or other auxiliaries or by fluid from a steam-jet ejector if such is used to withdraw air from the condenser. The boiler *b* may supply a separate turbine. (British

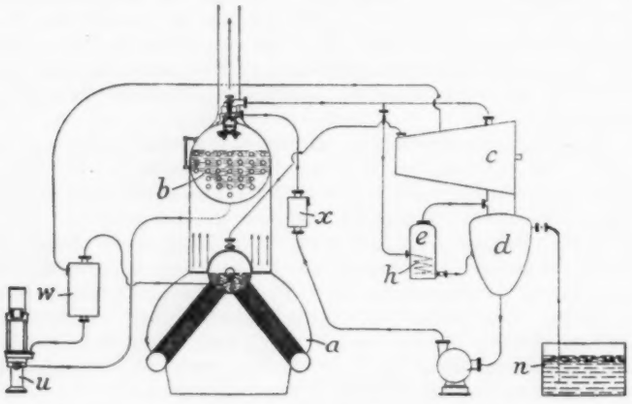


FIG. 7 COMPOUND AND COMPOSITE BOILERS

Patent No. 244,541, granted to G. &. J. Weir, Ltd., Cathcart, Glasgow. *The Illustrated Official Journal* (*Patents*), no. 1934, Feb. 10, 1926, p. 6741, *d*)

SPECIAL MACHINERY

The Bliss "Cluster" Rolling Mill

DESCRIPTION of a cold-rolling mill of novel design, now being used for the production of high-finish monel metal and nickel sheets at the Huntington, W. Va., plant of the International Nickel Co.

It has been known for a long time that rolls of small diameter have certain advantages for rolling. Their disadvantage lies, however, in their lack of strength and rigidity. To meet this condition the Lauth mill was developed a good many years ago. In this mill each of the small rolls which came in actual contact with the metal was backed by a big roll, which in this way reinforced the small roll and prevented it from buckling and spreading. The Bliss "cluster" roll is a further development of the principle of the Lauth mill. Each of the two working rolls is backed by two support rolls, so arranged that lines connecting the centers of the circular cross-sections of each set of rolls form isosceles triangles, while the extension of the line connecting the centers of the working cylinders substantially makes right angles with the opposite and parallel bases of the two triangles.

The working rolls are of hardened steel 12 in. in diameter, and the backing-up rolls are of milled cast iron about 24 in. in diameter. All of the backing-up rolls are adjusted for alignment. The bottom rolls are adjusted by means of wedges under the bearings, and the top rolls by screws which are placed at an angle so that their center lines will coincide with the angle of pressure on the rolls. To operate these screws, a special screw-down was designed powerful enough so that an operator could drive the rolls together with great force. In fact, the screw-down is so powerful that an operator can adjust the rolls while the sheet is going through the mill. To transmit sufficient power to these working rolls the old type of pinion housing was abandoned and drives arranged on both sides of the roll stand. The drive on one side operates the top working roll. These two drives are connected to one motor by means of a connecting shaft, which insures the driving of both working rolls at the same period.

By the use of two backing-up rolls for each working roll, the enormous pressure necessary to reduce the sheets is divided between two roll contact surfaces. This reduces the contact pressure of the chilled-iron backing rolls, prevents the spalling of the chilled-iron surface, and greatly increases the amount of rolling for each regrinding of the backing-up rolls. The pressure is also distributed to four near bearings in place of two neck bearings as would be the case if only one backing-up roll were used. (Lloyd Jones, Engr., E. W. Bliss Co., Brooklyn, N. Y., in *Blast Furnace and Steel Plant*, vol. 14, no. 4, Apr., 1926, pp. 180–201, *d*)

A Speed Governor for Small Hydraulic Installations

THE governor here described is of the electrical-energy absorption type. The principle is not new but the design apparently is. The governor requires the presence of an electric generator driven from the turbine directly or through a transmission. In principle, therefore, it is applicable only to hydroelectric installations. Actually, however, it may be applied even where the water turbine drives directly some mechanical device without any intervention of electrical energy, because even then there is usually an electric generator operated to give current for lighting.

The governor consists of the following parts: First, a specially designed tachometric spring pendulum endowed with a considerable amount of energy. This pendulum is operated by the mechanism the speed of which is to be governed: namely, where the turbine drives directly a mechanical device, by the speed of this latter, and where water power is converted into electrical energy, by a special electric motor or by a drive from the motors of the installation.

Next, there is a system of electrodes connected through a flexible connection to an electric circuit receiving current from the generators. These electrodes dip into a metal tank containing a conducting salt solution. The tank is enclosed in another tank in which cooling water circulates.

Third, a system of levers operated by the sleeve of the pendulum and carrying the electrodes which are immersed to a greater or less extent in the tank according to the position of the pendulum sleeve. If the speed increases the pendulum sleeve rises, and when this happens the electrodes sink deeper into the conducting solution. The generator then increases its current output and acts as a brake on the turbine. In this way there is produced an equilibrium between the motor effort of the turbine and the resistance effort opposing it.

One of the interesting particulars of this apparatus is its great sensibility. It is said to be possible to bring into perfect equilibrium the levers and the electrodes suspended therefrom, in which case the tachometer functions as a free governor (which means with its sensibility at a maximum). In practice the apparatus is set in tests for 2.5 per cent. Furthermore, the governing of the apparatus may be easily modified, while the power absorbed by the apparatus is said to be quite insignificant. As a matter of fact, it is possible to regulate the position of the electrodes with respect to the surface of the liquid in such a manner that when the installation is absorbing its maximum power the electrodes are submerged to an extent of only 1 or 2 mm. (0.04 or 0.08 in.). The power absorbed in the tank is then from 200 to 300 watts. The power absorbed by the pendulum is also extremely small, as it runs on ball bearings and all the gearing is enclosed in an oil bath. In plants where the load is not subject to very great and very rapid variations the governor operates without oscillation or hunting. (R. Cabaud in *Revue de l'Ingénieur*, vol. 23, no. 2, Feb., 1926, pp. 52–54, 1 fig., *d*)

TESTING AND MEASUREMENTS

Pressure Waves Recorded Photographically

DATA on an investigation by W. Payman and H. Robinson of the British Safety in Mines Research Board. In photographing pressure waves two difficulties have to be overcome. The first is that the wave is invisible, and the second that the speed of the wave is too great to permit ordinary methods of taking so-called instantaneous photographs to be used. In the present investigation

the Topler method was used. At M, Fig. 8, is located a concave mirror of stainless steel, 46 cm. in diameter and 1.83 m. in focal length. Then there is a source of illumination, and at C a recording camera. An opaque diaphragm D with its edge horizontal is placed in front of the lens so as to cover its lower half. AB indicates the plane in which are set up the striae to be photographed. In use, the camera is placed in such a position that the image of the source of light is brought to a sharp focus on the diaphragm D. The camera itself is focused on the plane AB. If there are no striations in the plane AB, the whole image is received on the diaphragm, and the sensitive plate in the camera is unexposed to it. If striae are present the deflection which they produce in the rays of light will cause the rays to pass beyond the edge of the diaphragm, through the camera lens and on to the sensitive plate, with the result that an image of the striations will be received.

To obtain short-exposure photographs the investigators used the spark produced by the discharge of a Leyden jar. Such a spark, it is believed, has a duration of about 1/10,000,000 of a second, and in addition has an actinic effect sufficient to act on a sensitive plate exposed to it for this short period. Electrical methods were used to obtain the synchronizing of the illuminating spark with the appearance in the field of view of the rapidly moving shock wave.

A method of measuring the speed of the wave was developed. It was found that with a particular setting of the diaphragm in front of the camera lens the wave front appeared in the photograph as an intense black line, and without anything but the outline of the wave

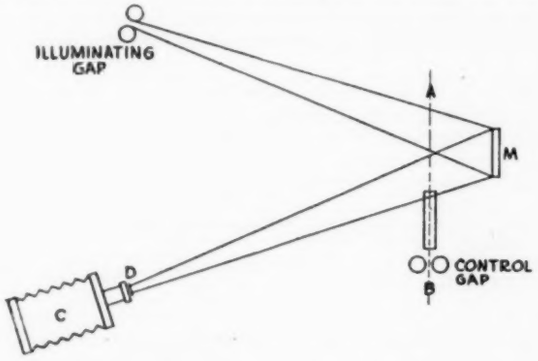


FIG. 8 SET-UP FOR TAKING PHOTOGRAPHS OF PRESSURE WAVES

being shown. With this setting of the diaphragm and a continuous source of illumination, a photograph was taken on a length of film stretched on a rapidly revolving drum. A continuous time-distance diagram showing the movement of the wave front was thus obtained. The film was moved vertically and in front of it a horizontal stenopaic slit was fitted. By this arrangement the outward spread of the wave was not recorded, and the position of the wave front at any instant was given by a spot of light, and the record of its movement by a clearly defined black line across the film.

In the original article are reproduced six of the photographs taken by Payman and Robinson by means of the Topler method described above. This series of photographs illustrates the propagation of combustion in a mixture containing 9.5 per cent of methane, when fired in a brass tube 2.5 cm. in internal diameter by means of an electric spark at the center of the tube. In the first and second views the mixture ejected from the tube in advance of the flame is shown. The remarkably beautiful symmetry assumed by the unburnt gas in the second view is very striking. In the third and fourth views the flame following the unburnt gas is seen. In the fifth and sixth views flame alone appears to be present. (Paper No. 18 of the British Safety in Mines Research Board, abstracted through *Automotive Industries*, vol. 54, no. 14, Apr. 8, 1926, pp. 606–608, 3 figs., *de*)

THERMODYNAMICS

The Heat Conductivity of Air and Hydrogen

DATA of tests carried out by the Schleiermacher method. The tests were carried out under conditions where the gas pressure, the temperature difference between the heated wire and the ambient medium, and the temperature of the ambient medium itself as well as the diameter of the wire, were varied. In particular, it was found that variations in the diameter of wire did not affect the heat conductivity in the case of hydrogen, but did to a small extent (1 per cent) in the case of air. The values for heat conductivity and temperature coefficient of hydrogen previously found by Weber were confirmed. For air, however, it was found in the present test that both were somewhat higher (about 4 per cent) than those determined by Weber. The actual values are given in the original article. (Ernst Schneider in *Annalen der Physik*, series 4, vol. 79, no. 3, 1926, pp. 177–203, 10 figs., *eA*)

WELDING

Stelliting

"STELLITING" is the term which has been applied to the process of flowing stellite on to a metal surface so as to unite with it and form a permanent coating. Stellite is an alloy consisting essentially of chromium, cobalt, and tungsten. It is therefore expensive and it is of advantage to use cheaper metal for the base and to apply just enough stellite to obtain the advantage of its peculiar properties.

Stellite can be applied by the oxyacetylene blowpipe to almost every metal in common use. Any grade of steel, as well as cast iron, semi-steel, and malleable iron, can be successfully stellited.

Stelliting, however, is not welding. In actually performing the operation a technique is developed which differs from any other operation with the blowpipe. First, the flame should be almost parallel to the surface being stellited, and two or three inches of the rod should be enveloped by the flame. This keeps the rod hot so that when the base metal just begins to "sweat" the stellite can be flowed on quickly. Speed is essential in order to get a very thin first coating, upon which later to build. Furthermore the horizontal flame lessens the possibility of heating too deeply into the base metal and forming a "crater" which causes trouble in obtaining a clean surface of pure stellite. A clean stellite surface, free from blowholes or iron alloy, is the effect that must be obtained.

The only other precaution to be emphasized is that all scale, dirt, or foreign material must be removed before the stellite surface is applied. If such material remains, it will cause blowholes which render the stellited part unfit for most purposes.

In industries where crushing and pulverizing equipment is used, the life of a screw conveyor to transport ground material has been increased by stelliting the first few flights where the great wear occurs. The ability of the alloy to retain its hardness at high temperatures accounts for its usefulness in the metal-cutting field. This is important because in many die operations, especially where forgings are trimmed, the work must be kept red hot during the operation.

An interesting application was found in the cement industry, where white-hot clinkers are taken away from the kiln by a drag chain. The supporting bar and plate on which the chain travels are subjected to the intense heat of the white-hot clinker and the abrasion of the chain at the same time. The riding bars surfaced with stellite have shown remarkable durability in this service.

An instance of the importance of resistance to chemical corrosion is found in the manufacture of dry batteries, where a number of dies and machine parts come into contact with active chemicals which tend to corrode and destroy the texture of the metal. Stelliting has greatly increased the life of dies and machine parts in cases of this sort.

The experimental work which has led up to the development of this process makes it possible for the owner of oxyacetylene-welding apparatus to secure all of the advantages of this unique alloy while making use of a minimum amount of it. (*The Welding Engineer*, vol. 11, no. 4, Apr., 1926, pp. 25–28, and paper by A. V. Harris, of the Haynes Stellite Co., read before the American Welding Society in Boston, *dp*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

International Organization for Standardization

THE basis of a general international organization for industrial standardization was laid at the Third International Conference on Standardization, which convened for two weeks in New York, April 12 to 23, 1926. A unanimous agreement upon the draft of a constitution for the new international body was reached. At this conference the national standardizing bodies in eighteen countries were officially represented, Hungary and Australia alone being without delegates.

The conference was called by the American Engineering Standards Committee, and was presided over by its chairman, C. E. Skinner.

The conference recommended that the seat of the new organization be in London, final decision to be made by the first Plenary Assembly. Work on technical questions will be in the hands of a "technical committee," with official representation from each country interested.

The conference appointed a committee of seven to formally submit the proposed constitution to the twenty national standardizing bodies, and to arrange for a Plenary Conference for final ratification and organization. The countries represented on the committee are: Belgium, Czechoslovakia, Germany, Great Britain, Sweden, Switzerland, and the United States.

During the sessions of the conference, informal negotiations were opened with the International Electrotechnical Commission (an important international body now functioning in the specialized field of electrical engineering) in regard to a unified organization, and the committee of seven will undertake to secure joint action in the final organization which it is expected will be consummated when the Plenary Assembly is held.

In connection with the main conference, informal conferences between technical experts were held on the subjects of screw threads, bolts and nuts, limits for fits, preferred numbers, and ball bearings.

Nearly all of the delegates to the conference accompanied the members of the International Electrotechnical Commission, as guests of the U. S. National Committee of the latter, on a tour of inspection by special train which made stops at Philadelphia, Washington, Pittsburgh, Chicago, Detroit, Windsor, Niagara Falls, Toronto, Ottawa, Montreal, Boston, and Schenectady, returning to New York on May 5. Following is a list of the delegates to the conference.

Austria

BRETTSCHNEIDER, P., Vice-Chairman, Oesterreichischer Normenausschuss für Industrie und Gewerbe (ONIG).

Belgium

UYTBORCK, E., Association Belge de Standardisation (A.B.S.).

Canada

DURLEY, R. J., Honorary Secretary, Canadian Engineering Standards Association (C.E.S.A.).

Czechoslovakia

LIST, V., Chairman, Ceskoslovenská Normalisacni Spolecnost (CNS).
ROSENBAUM, B., Secretary, Ceskoslovenská Normalisacni Spolecnost (CNS).

Denmark

Represented by the Swedish delegates.

Finland

Represented by the Swedish delegates.

France

DARRIEUS, G. J., Fédération des Syndicats de la Construction Mécanique, Electrique et Métallique.
GIRAULT, P., Union des Syndicats de l'Electricité.
ROTH, E., Fédération des Syndicats de la Construction Mécanique Electrique et Métallique.

Germany

KIENZLE, OTTO, Normenausschuss der deutschen Industrie (N.D.I.).
MAIER, A., Normenausschuss der deutschen Industrie (N.D.I.).

Great Britain

ATKINSON, L. B., British Engineering Standards Association.
CROMPTON, COL. R. E., C. B., British Engineering Standards Association.
DENNY, SIR ARCHIBALD, Bart., Chairman, British Engineering Standards Association.
GLAZEBROOK, SIR RICHARD, British Engineering Standards Association.
LE MAISTRE, C., C. B. E., British Engineering Standards Association.
SPARKS, C. P., British Engineering Standards Association.

Holland

TROMP, W. H., Secretary, Central Normalisatie Bureau, Delegate, Main Committee Dutch Standardization.

Italy

BATTI, N., Comitato Generale per l'Unificazione nell'Industria Meccanica.

Japan

INOMATA, M. Y., Japanese Engineering Standards Committee.
KONISHI, SHOJI, Japanese Engineering Standards Committee.

Norway

HEIBERG, K., Secretary, Norges Industriforbunds Standardiseringskontor.

Poland

DRZEWIECKI, P., Chairman, Polski Komitet Normalizacyjny.
ROGINSKI, A., Secretary, Polski Komitet Normalizacyjny.

Russia

CHATELAIN, M., Vice-President, Committee of Standardization.
LAPIROFF-SCOBLO, M., Committee of Standardization.
ZISCHIEVSKY, J., Committee of Standardization.

Sweden

ENSTROM, A. F., Chairman, Svenska Industriens Standardiseringskommission.
KRUSE, A., Secretary, Svenska Industriens Standardiseringskommission.
OSTERBERG, S. E., Assistant Secretary, Svenska Industriens Standardiseringskommission.

Switzerland

HOENIG, C., Chairman, Schweizerische Normalien-Vereinigung.

United States

AGNEW, P. G., Secretary, American Engineering Standards Committee.
BURGESS, G. K., American Engineering Standards Committee.
SKINNER, C. E., Chairman, American Engineering Standards Committee.

The proposed constitution of the new organization, which is to be called the International Standards Association, is reproduced below for the information of our readers.

PROPOSED CONSTITUTION FOR AN INTERNATIONAL STANDARDS ASSOCIATION

(Unanimously agreed upon by the Third International Conference on Standardization, New York, April, 1926)

SECTION 1—*Title.* The name of the organization shall be the International Standards Association (I.S.A.).

SECTION 2—*Aims and Objects.* The aims and objects of the International Standards Association are:

(*a*) To lay the groundwork for international agreement upon standards by providing simple systematic means of interchanging information on the standardization work and activities in the different countries.

(*b*) To develop general guiding principles for the assistance of the national standardizing bodies.

(*c*) To promote uniformity among the standards of the various national bodies.

(*d*) It is the intention of the International Standards Association that its work shall include the approval of international standards, and the administrative machinery herein set up is so designed that it may be readily extended or modified to include the approval of such international standards when sufficient experience has been acquired.

SECTION 3—*Membership.* The International Standards Association shall be composed of the central National Standardizing Bodies existing in the different countries, one for each country, which have accepted this constitution.

SECTION 4—*Plenary Assembly.* (*a*) The chief executive body of the International Standards Association shall be the Plenary Assembly, composed of delegates nominated by the national bodies. The final authority rests with the national bodies.

(*b*) A Plenary Assembly can be called by the President, or in case of his inability to act, by two members of the Administrative Council. The Ad-

ministrative Council shall call a meeting of the Plenary Assembly upon the request of—national bodies. The date and place of meeting shall be fixed by the Administrative Council. Six months' notice of a Plenary Assembly shall be given, except in the case of the first Assembly.

(*c*) The Plenary Assembly shall be presided over by the President of the National Standardizing Body in the country in which the Assembly is held.

(*d*) As a general rule, Plenary Assemblies will be convened once in three years.

SECTION 5—*Voting Power.* At a Plenary Assembly each National Standardizing Body shall be entitled to one vote only, either by person, by proxy, or by correspondence, whatever the number of delegates it may send to the meeting. All questions except those for which provision is made in this constitution shall be decided by a majority of the members voting.

SECTION 6—*Officers.* (*a*) The Plenary Assembly may confer the title of Honorary President on persons of distinction whose coöperation it is desired to enlist.

(*b*) The President shall be elected by the National Standardizing Bodies either in Plenary Assembly or by correspondence; he shall hold office for a period of three years and shall be ineligible for reëlection until a further period of six years has elapsed.

(*c*) Each national body shall designate a Vice-President of the I.S.A.

(*d*) A General Secretary shall be appointed by the Plenary Assembly. He shall attend the meetings but without power to vote.

(*e*) The Officers of the International Standards Association shall retain office until their successors have been appointed.

SECTION 7—*Administrative Council.* (*a*) An Administrative Council shall be appointed by the Plenary Assembly and shall be composed of the President of the I.S.A. and four other members on nomination by selected National Standardizing Bodies, with a power for the President to call other persons to attend, but without vote. In the case of death or inability of the member to serve on the Administrative Council, the National Standardizing Body concerned may nominate one of its members to act in his place.

(*b*) Provision shall be made in by-laws for rotation in office.

(*c*) The Administrative Council shall call such meetings and take such steps as it may think desirable to facilitate the progress of the work. It can agree by correspondence.

(*d*) The Administrative Council shall be responsible for all financial matters.

(*e*) The Administrative Council shall take no technical decisions.

(*f*) The reports of the meetings of the Administrative Council shall be circulated to all member National Standardizing Bodies without delay.

(*g*) The traveling expenses of the members of the Administrative Council shall be paid by the respective National Standardizing Bodies.

(*h*) The Administrative Council shall meet at least once each year.

SECTION 8—*Central Office.* (*a*) The Plenary Assembly shall decide on the locality of the seat of the International Standards Association and the Central Office of the Association shall be established in accordance with this decision.

(*b*) The Central Office shall be under the supervision of the General Secretary acting in accordance with the instructions of the Plenary Assembly and of the Administrative Council.

(*c*) It shall be the business of the Central Office to circulate among the members all information available as to standardization matters of importance to the work of the Association and in every way to further international agreement on such matters.

(*d*) Formal business of the International Standards Association shall be conducted by correspondence between the Central Office and the National Standardizing Bodies.

SECTION 9—*Technical Committees.* (*a*) Technical Committees are committees appointed for the purpose of studying technical subjects having an official status in the Association, as provided in Section 10 (*a*) and (*b*).

(*b*) Each technical committee shall consist of one official delegate from each of those National Standardizing Bodies desiring to take part in the work of the Committee. Additional unofficial delegates may be appointed.

SECTION 10—*General Procedure.* (*a*) On receipt of a request from one or more Member Bodies to study a technical subject, the Central Office shall at once inform all Member Bodies, asking whether they are in favor of a Technical Committee being formed to study the subject, and, if so, whether they wish to nominate a delegate, should a Technical Committee be formed. The Central Office shall then place the matter before the Administrative Council, together with the replies received.

(*b*) If the majority (not being less than three) of the members voting are in favor of a Technical Committee being appointed, then such committee shall be appointed by the Administrative Council. [See Section 10 (*j*).]

(*c*) Before a Technical Committee is organized, the scope of the work, or terms of reference, shall be clearly outlined, and no Technical Committee shall go beyond the work outlined for it.

(*d*) The Administrative Council, in consultation with the Technical Committee concerned, shall appoint either the Central Office or one of the National Standardizing Bodies to act as Secretariat for that Technical Committee. The Secretary so appointed shall be responsible to the Administrative Council for the work, including all correspondence.

(*e*) Meetings of Technical Committees shall be arranged in consultation with the delegates, either by the Central Office or by the National Standardizing Body appointed to act as Secretariat for the subject in hand.

(*f*) The General Secretary ex-officio shall have the right to attend all meetings of the Technical Committees and take part in the discussions, but without the power to vote.

(*g*) A report of each Technical Committee meeting shall be sent to the members of that Committee and to the General Office.

(*h*) The Administrative Council shall be authorized on behalf of the Association to instruct the Central Office to keep all national bodies in touch with all subjects having official status, by reports and memoranda. This is a general rule, action not being required in individual cases.

(*i*) The Secretary of any Technical Committee shall submit the proposals of that Technical Committee to the National Standardizing Bodies appointing delegates. When the Technical Committee has reached agreement, its proposals shall be sent to the Central Office to be dealt with in accordance with Section 10 (*h*).

(*j*) If a request has been received from one or more bodies for a Technical Committee, but it has been decided not to appoint such a Committee, then the group of national bodies interested in the subject shall be encouraged to come to agreement with regard to them. Such an agreement shall not be considered as a decision of the Association.

SECTION 11—*Units Employed.* English and metric measures shall be used in the published recommendations of the International Standards Association. Conversions shall always be given unless otherwise decided by the Administrative Council.

SECTION 12—*Funds.* (*a*) The financial support of the central office shall be divided into three parts:

1 A sum amounting to 25 per cent of the total budget divided equally among the national bodies.

2 A sum amounting to 50 per cent of the total annual budget divided in proportion to the average total foreign trade of each country during the preceding three years.

3 A sum amounting to 25 per cent of the total annual budget, divided in proportion to the population of each country.

NOTE: Assuming a first budget of £2000 per year, these amounts would be:

1 Fixed sum for each national body £25
2 For every hundred million pounds total foreign trade ..... 12£ 10 s.
3 For each million inhabitants £1

Increases in these amounts in subsequent budgets shall be subject to the approval of the national bodies.

(*b*) Each National Standardizing Body joining in the work of the Commission shall agree to contribute to the expenses of the Commission for three years and shall give not less than one year's notice if they desire to retire.

(*c*) In the event of the expenses in any one year being less than the amount contributed, the Administrative Council shall establish a Reserve Fund, and fix the maximum, after which any sum unexpended shall be deducted from the contributions due from the National Committees for the subsequent year pro rata.

SECTION 13—*Accounts.* The accounts of the Central Office, which shall be made up annually to the 31st December, shall be submitted to the Administrative Council before the 31st March in each year and shall be signed by the President and by the General Secretary. In the case of the inability of the President to do so, they shall be signed by one of the other members of the Administrative Council on his behalf. The report of a professional auditor shall be accepted as proof of the correctness of the accounts.

SECTION 14—*Alteration of Statutes.* Any future alteration to these Statutes can only be effected by a vote of four-fifths of the participating National Standardizing Bodies and after ratification by a Plenary Assembly.

SECTION 15—*Liquidation.* In case of the International Standards Association being dissolved, the Administrative Council shall decide upon the disposal of the remaining funds.

International Conference of Experts on Standardization of Bolts and Nuts

STANDARDS for bolts and nuts was the subject of a special conference during the Third International Standardization Conference held under the auspices of the American Engineering Standards Committee.

Soon after the war the Germans adopted national standards for width across flats of square and hexagonal bolt heads and nuts and the corresponding wrench openings. This was followed by similar action in Austria, Holland, Sweden and Switzerland, with the result that nuts, wrenches, and bolt heads are interchangeable in all these countries. In the United States, a large amount of work has been done also during the last three years by the Sectional Committee on Standardization of Bolt, Nut, and Rivet Proportions.

We are informed that in adopting their present standards, the Continental countries thought they were closely following American practice. Essentially what they did was to accept the so-called "United States Standard," rounding the wrench openings to the nearest millimeter. The American delegates stated that in fact this list of sizes now represents less than three per cent of the production in this country. They pointed to the experience of the automobile and agricultural machinery industries as confirming the soundness of the proposed new standards.

The conference formally requested the British Engineering Standards Association to continue its experiments and to send the results to all of the twenty national standardizing bodies. These data could then be considered in connection with proposals which have been advanced, as a basis of international standardization, by the Swiss and by the Americans.

Correspondence

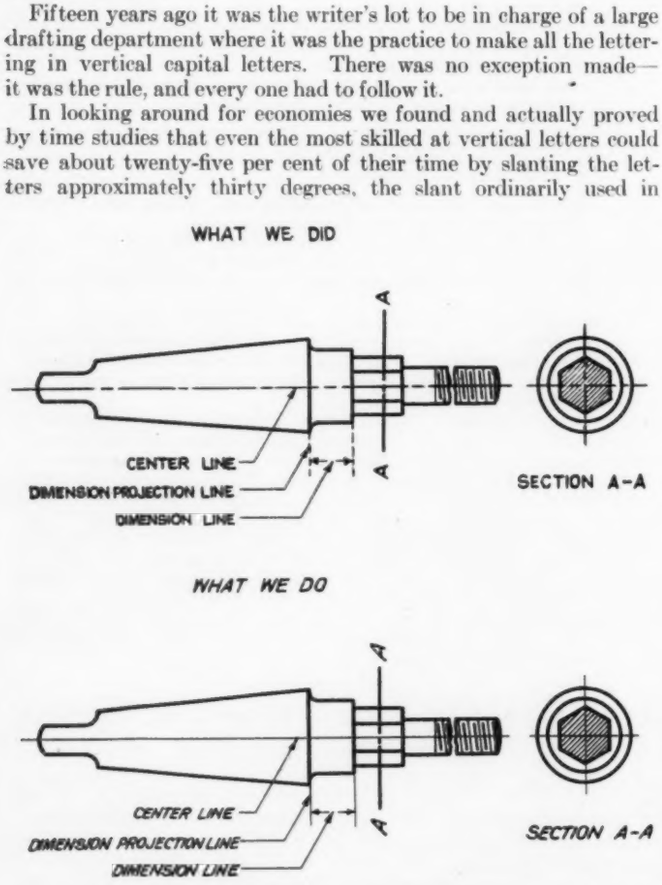
CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Slanting Letters on Drawings Save Money

TO THE EDITOR:

Fifteen years ago it was the writer's lot to be in charge of a large drafting department where it was the practice to make all the lettering in vertical capital letters. There was no exception made—it was the rule, and every one had to follow it.

In looking around for economies we found and actually proved by time studies that even the most skilled at vertical letters could save about twenty-five per cent of their time by slanting the letters approximately thirty degrees, the slant ordinarily used in



writing. The plain vertical capital letters looked so well on the drawings, and the practice had become so well established in the drafting room and by those who used the drawings in the shop, that the suggestion to change to the slanting letters would not even have been considered had it not carried with it the statement that it would effect a saving of several thousand dollars a year—there being hundreds of draftsmen employed. It is also interesting to know that there was no inconvenience caused in making the change. The draftsmen who had specialized on vertical lettering were more than willing to change to the slanting letter.

Another suggestion is the use of one straight line instead of different kinds of dotted lines to show the center line, the dimension line, and a dimension projection line. We found that our several drafting departments were not following the same practice but used a dot-and-dash line, a dotted line, and a line made up of dashes indiscriminately for the three different requirements. Schools and colleges were also teaching various practices.

In trying to get our department chiefs to agree on one practice, we found that each one was reluctant to give up the particular style he had been used to, so we compromised by having everybody give up his practice and use a straight, thin line for all three. The making of these changes resulted in effecting the highest economy in two seemingly simple yet fundamental drafting practices.

The committee on the standardization of drawing practices, which the A.S.M.E. is to appoint, will be asked to consider styles of lettering that can be made in less time than the slanting gothic capitals, but from the writer's experience—and that covers more than a quarter of a century—there is no other letter so serviceable day in and day out, to the man in the shop, as the style referred to above. Let it be added that if the members of the committee ignore the opinions of the men in the shop, they will be riding for a fall.

JOHN HARPER.[1]

Chicago, Ill.

The Question Mark in Machine Design

TO THE EDITOR:

My attention has been called to the paper by Mr. Forrest E. Cardullo entitled The Question Mark in Machine Design, which appeared in the Mid-November, 1925, issue of MECHANICAL ENGINEERING.

Among other things the author cites the conventional G-frame, Fig. 1, as an illustration of an erroneous design, and goes so far

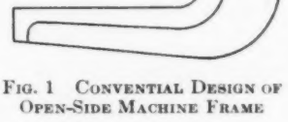


FIG. 1 CONVENTIAL DESIGN OF OPEN-SIDE MACHINE FRAME

FIG. 2 PROPER METHOD OF DESIGNING AN OPEN-SIDE MACHINE FRAME

as to label it a mechanical monstrosity. But why a monstrosity? Does Mr. Cardullo have experimental or theoretical evidence that his proposed design is superior? He certainly does not give such evidence in his paper.

Whatever may be the merits or faults or the conventional design, the proposed one, Fig. 2, is, if not inferior, by no means better, for the simple reason that the bad features which Mr. Cardullo condemns are in reality much magnified in his proposed design.

Mr. Cardullo says that the stresses in the flange are greatly intensified where the flange is curved. Quite true. But in making the corners sharper, that is, making the radius of the fillet smaller, as the author does, the curvature is greatly increased, thereby bringing into more pronounced play the very features he criticizes.

The conventional design has the advantage of a fillet of largest possible radius, and consequently smallest curvature, thus reducing the extra stresses to a minimum.

M. M. FROCHT.[2]

Pittsburgh, Pa.

The "Therm" as a Unit of Boiler Capacity

TO THE EDITOR:

Few who deal extensively in technical terminology and calculation will fail to agree that that incubus of the past—the "boiler horsepower" as a measure of boiler capacity—is, or at least should be, as extinct as those well-known antedeluvian twins, the dinosaur and the diplodocus. Its continuing recurrence among the misguided can only be attributed to the lack of an acceptable substitute to date.

Many have turned to "square feet of heating surface." To be consistent such persons should rate motor sizes in "square feet of exposed coil" and turbines in "square inches of blade area." As

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[2] Mechanics Department, Carnegie Institute of Technology.

a measure of capacity, such terms tell just enough of the story to be confusing. Radiant-heat-absorbing surface which "sees" the fire bears as little relation to the convection surfaces of the various passes as the exposed areas of the interpoles and of the armature coils or of the turbine-blade areas in the first and last stages. None of these quantities represent more than one of the several contributing causes which go to make up a desired result.

Others more logically inclined have proposed "pounds of steam per hour" as a preferable term. There are two principal objections to this. First and least, modern boiler sizes necessitate unduly lengthy strings of zeros, some of which the printer at times may inadvertently omit, and which in calculations prove frequently most inconvenient. More particularly, however, the term leads to confusion unless the lengthy and unwieldy "from and at 212 deg." differentiates it from steam "at delivered pressure and temperature."

In England in the gas industry a term has been universally accepted which, it is believed, would lend itself ideally to the solution of this problem. The American gas industry has recently seized on and is accepting it. This term is the "therm," which is equal to 100,000 B.t.u. The "therm-hour" (t-h.), therefore, would be roughly a little less than three boiler-horsepower-hours or about what ten square feet of surface are called on to average at the modern rating of 300 per cent. It is easy to say and to abbreviate. It conveys a distinct idea of heat quantity. It is a unit which in boiler practice can be expressed in three or four figures. Its extensive use in the gas industry to date has so far failed to reveal faults of lexicography.

It may be contended that it was the original purpose of the committee of the British Association who first proposed the term in 1896 that it be used instead of the unwieldy and confusing "gram-calorie." Later, others proposed it as a substitute for "kilogram-calorie" and still others as one for 1000 "calories." In spite of its inclusion in various dictionaries under one or more of these definitions, it is believed that those familiar with present-day literature of the gas industry will agree that the universally accepted significance of the term today indicates but one thing and one thing only, namely, 100,000 B.t.u.

Is there a better term or are there unsurmountable practical difficulties confronting the acceptance of this proposed new term? Public use is the sole criterion of a word's existence in technical parlance. Let us have an expression of views. Let's agree on *something* to rid ourselves of an irritating Babel of half-accepted makeshifts.

H. W. BROOKS.[1]

Fullerton, Pa.

Design and Test of Susquehanna Station

TO THE EDITOR:

The article on the Susquehanna Station of the Metropolitan Power Company in the April issue of MECHANICAL ENGINEERING is one of the most complete and valuable articles on power-house economy that has been published in some time. The writer notes, however, an inconsistency in the calculations of heat transmission contained in the condenser-test section which he believes should be corrected.

The condenser surface is given as 45,000 sq. ft.; the test data contained in the article are reproduced below.

TABLE 5 CONDENSER PERFORMANCE

Pressures	Test OT	Test ST
Barometer, in. Hg	29.87	29.79
Vacuum (by mercury column), in. Hg	27.75	27.86
Pressure, absolute, in. Hg	2.12	1.93
Water Temperatures		
Circulating inlet, deg. fahr.	82.6	81.6
Circulating discharge, deg. fahr.	91.3	89.0
Condensate, deg. fahr.	100.5	96.4
Results		
Steam condensed per hr., lb.	268,000	238,200
Quantity of condensing water per hr. (c) lb.	31,900,000	33,450,000
Quantity of condensing water (c) gal. per min.	63,800	66,800
Heat transfer per deg. diff. temp. per sq. ft. per hr., B.t.u.	483	491

Using the absolute pressures and the inlet and outlet water temperatures from tests OT and ST, and assuming each pound of steam to give up 940 B.t.u. to the circulating water, coefficients of 356 and 347, respectively, are calculated for these tests. Due to some error, the coefficients are shown as 483 and 491—or 35 and 40 per cent higher than as calculated by the writer from the data given. There is either an error in the data given or in the heat-transfer rates published.

Would it not be better to use a direct check from the vacuum results expected, or guarantees made, to the vacuum obtained on test, thus eliminating a comparison of derived quantities. In this case the various guarantees are not given in the article, but it is stated that the condenser guarantees indicate a coefficient of 450. With this as a basis and using the water temperatures and loads tabulated above, we arrive at the following expected vacuums:

	Test OT	Test ST
Vacuum expected with a 450 coefficient, in. Hg	28.08	28.25
Vacuum obtained, in. Hg	27.88	28.07
Difference, in. Hg	0.20	0.18

It is the writer's opinion that there is less chance for error by reporting results in this form, namely, comparisons of vacuum obtained and expected rather than comparison of derived figures of heat transfer. This is the official method laid down in the A.S.M.E. Power Test Codes for Condensers, page 14, item 137.

Attention is particularly called to this apparent discrepancy because of the very little information available on large condensers.

J. N. LANDIS.[1]

The Earnings of Engineers

TO THE EDITOR:

The communication of Mr. H. M. Dougherty published in the April issue of MECHANICAL ENGINEERING, under the heading The Earnings of Engineers, raises questions of great interest to all members of the profession.

It may be true, as Mr. Dougherty suggests, that some engineers, under a mistaken idea as to the true nature of altruism, encourage the public to believe that the acceptance of services for less than their fair value is a virtue instead of a vice, as it really is, and thus make themselves accessories before the fact. At the same time I am sure that there are many of us who will heartily agree with Mr. Dougherty that we should be interested in obtaining adequate remuneration for engineering service.

The question as to whether our Society and those with which it is closely allied should take direct action with a view to increasing the salaries and fees of engineers, is one concerning which there may be a legitimate difference of opinion. Personally, I am inclined to think that our hands are so full with the more scientific problems of engineering that the actual work of improving conditions had better be left to others. At the same time, a scientific investigation into the causes of the present state of affairs, with a view to eliminating those which are detrimental, is work which I think might be undertaken by all our engineering societies.

Engineering services, like labor and commodities, are subject to the law of supply and demand, and undoubtedly the first thing for us to do, if we are to exercise an intelligent supervision of the supply, is to obtain as complete information as possible about the nature of the demand. There is no doubt that the field in which technically trained men could be beneficially employed is much wider than is generally supposed, but if we are to take full advantage of it, we must make a full investigation of the conditions and prepare our men accordingly. In other words, we should use the same business sagacity that is used by the progressive manufacturer. Having seen the possibility of a new market, we should design our goods to fit it, and then sell the idea to the public.

I heartily endorse Mr. Dougherty's suggestion that the leading engineering societies should coöperate, at least in so far as the work of making an investigation of the conditions is concerned.

J. O. G. GIBBONS.[2]

Newark, N. J.

[1] Consulting Engineer, Fuller Lehigh Co. Mem. A.S.M.E.

[1] Investigating Engineer, Mechanical Engineer's Department, Brooklyn Edison Co., Brooklyn, N. Y.

[2] Consulting Engineer. Mem. A.S.M.E.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision in the Rules in its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

During the past two years the Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals, and all deleted matter in smaller type.

Revisions and Addenda

PAR. P-9 REVISE FIRST SECTION TO READ:

P-9 When the maximum allowable working pressure (see Par. P-179) exceeds 160 lb. per sq. in., cross-pipes connecting the steam and water drums of water-tube boilers, headers, cross-boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings. WHEN ROUND OR SQUARE TUBING MATERIAL IS USED FOR THE CONSTRUCTION OF SINUOUS HEADERS OF BOILERS WHICH CONFORMS TO THE SPECIFICATIONS FOR BOILER TUBES OR OTHER PIPE MATERIALS AS CONTAINED IN SECTION II OF THE CODE, THE FLATTENING, CRUSHING, OR BENDING TESTS ARE NOT REQUIRED AS THE WORK DONE ON THE MATERIAL FORMING THE SINUOUS HEADER TAKES THE PLACE OF THESE TESTS. Malleable iron, as designated in the Specifications for Malleable Castings, may be also used when the maximum allowable working pressure does not exceed 350 lb. per sq. in., provided the form and size of the internal cross-section perpendicular to the longest dimension of the box, is such that it will fall within a 7-in. by 7-in. rectangle.

PAR. P-194 REVISE FIRST TWO SECTIONS TO READ:

P-194 Domes. The longitudinal joint of a dome 24 in. or over in inside diameter shall be of butt and double-strap construction, or made without a seam of one piece of steel pressed into shape, and its flange shall be double-riveted to the boiler shell. In the case of a dome less than 24 in. in diameter, for which the product of the inside diameter and the maximum allowable working pressure does not exceed 4000 in-lb., its flange may be single-riveted to the boiler shell and the longitudinal joint may be of the lap type, provided it is computed with a factor of safety not less than 8.

[The longitudinal joint of a dome less than 24 in. in diameter may be of the lap type, and its flange may be single-riveted to the boiler shell provided the maximum allowable working pressure on such a dome is computed with a factor of safety of not less than 8.]

PAR. P-197 REVISED:

P-197 The corner radius of an unstayed dished head measured on the concave side of the head shall not be less than [$1^1/_2$ in. or more than 4 in. and within these limits shall be not less than 3 per cent of *L* in Par. P-195] 3 TIMES THE PLATE THICKNESS UP TO $t = {}^1/_2$ IN. FOR THICKER PLATES THE CORNER RADIUS SHALL NOT BE LESS THAN 3 PER CENT OF *L* AND IN NO CASE LESS THAN $1^1/_2$ IN.

PAR. P-200 REVISE FIRST SENTENCE TO READ:

P-200 Staybolts. The ends of staybolts or stays screwed through plates SHALL EXTEND BEYOND THE PLATE NOT LESS THAN TWO THREADS WHEN INSTALLED, AFTER WHICH THEY shall be riveted over or upset by AN equivalent process WITHOUT EXCESSIVE SCORING OF THE SHEETS; OR THEY SHALL BE fitted with THREADED nuts THROUGH WHICH THE BOLT OR STAY SHALL EXTEND.

PAR. P-204 REVISED:

P-204 The formula in Par. P-199 was used in computing Table P-6. Where values for screwed stays with ends riveted over are required for conditions not given in Table P-6, they may be computed from the formula and used, provided the pitch does not exceed $8^1/_2$ in. WHERE THE STAYBOLTING OF SHELLS OF BOILERS IS UNSYMMETRICAL BY REASON OF INTERFERENCE WITH BUTT STRAPS OR OTHER CONSTRUCTION, IT IS PERMISSIBLE TO CONSIDER THE LOAD CARRIED BY EACH STAYBOLT AS THE AREA CALCULATED BY TAKING THE DISTANCE FROM THE CENTER OF THE SPACING ON ONE SIDE OF THE BOLT TO THE CENTER OF THE SPACING ON THE OTHER SIDE.

PAR. P-218 REARRANGE THE FIRST SENTENCE TO READ:

P-218 When stays are required the portion of the heads below the tubes in a horizontal-return tubular boiler shall be supported by through stays with nuts inside and outside at the front head and by attachments which distribute the stress at the rear head.

PAR. P-230*b* CHANGE THE REFERENCE TO "PAR. P-212*b*" NEAR THE END OF THIS PARAGRAPH TO READ "PAR. P-212*d*."

PAR. P-274 REVISE SECOND SECTION TO READ:

The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose, only the tubes, fireboxes, shells, tube sheets and the projected area of headers need be considered. The minimum number and size of safety valves required shall be determined on the basis of the aggregate relieving capacity and the relieving capacity marked on the valves by the manufacturer. Where the operating conditions are changed, OR ADDITIONAL HEATING SURFACE SUCH AS WATER SCREENS OR WATER WALLS IS CONNECTED TO THE BOILER CIRCULATION, the safety-valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with Par. P-270.

PAR. P-291 REVISED:

P-291 Water Glasses and Gage Cocks. Each boiler shall have at least one water-gage glass, WITH CONNECTIONS NOT LESS THAN $^1/_2$-IN. PIPE SIZE. The lowest visible part of THE WATER GLASS [which] shall be not less than 2 in. above the lowest permissible water level. THE WATER-GAGE GLASS SHALL BE EQUIPPED WITH A DRAIN.

The lowest permissible water level shall be that at which there will be no danger of overheating any part of the boiler when it is operated with the water not lower than that level. This level for the usual types of boilers is given in Par. A-21 of the Appendix.

PAR. P-293 REVISED:

P-293 When shut-offs are used on the connections to a water column, they shall be either outside-screw-and-yoke type gate valves or stop cocks with levers permanently fastened thereto and marked in line with their passage; and such valves or cocks shall be *locked or sealed open*. WHERE STOP COCKS ARE USED THEY SHALL BE OF A TYPE WITH THE PLUG HELD IN PLACE BY A GUARD OR GLAND.

PAR. P-295 REVISED:

P-295 No outlet connections, except for damper regulator, feedwater regulator, drains, [or] steam gages, OR APPARATUS OF SUCH

FORM AS DOES NOT PERMIT THE ESCAPE OF AN APPRECIABLE AMOUNT OF STEAM OR WATER THEREFROM, shall be placed on the pipes connecting a water column to a boiler.

PAR. P-297 REVISED:

P-297 The dial of the steam gage shall be graduated to approximately double the pressure at which the SAFETY VALVE IS SET [boiler will operate] but in no case to less than $1^1/_2$ times THIS [the maximum allowable working] pressure [of the boiler].

PAR. P-299 REVISE FIRST TWO SECTIONS TO READ:

P-299 Fittings. Flanged cast-iron pipe fittings [including those for steam and for feedwater and where the pressures do not exceed 160 lb.] shall conform to the American Standard given in the Appendix. If the fittings are below the water line they shall be extra heavy.

[For pressures exceeding 160 lb. per sq. in., fittings more than 2-in. pipe size or equivalent cross-sectional area, shall be of cast or forged steel (see Pars. P-9 and P-245). The dimensions of the flanges and drilling shall conform to the American Standard given in Table A-6.]

PAR. P-301 REVISED:

P-301 Stop Valves. Each steam-discharge outlet, except safety-valve and superheater connections, shall be fitted with a stop valve located as near the boiler as practicable. When such outlets are over 2-in. pipe size, the valve or valves used on the connection shall be of the outside-screw-and-yoke RISING-SPINDLE type.

PAR. P-310 REVISED:

P-310 The blow-off piping, and any piping or fittings connecting them to the boiler, shall conform to the requirements of Par. P-25. The blow-off valves shall be the full size of the blow-off pipes. All fittings between the boiler and valves shall be of steel. FOR PRESSURES OVER 250 LB. PER SQ. IN., THE VALVES OR COCKS SHALL BE OF STEEL CONSTRUCTION.

PAR. P-321 REVISED:

P-321 The water connections to the water column of a boiler, when practicable, shall be provided with a cross at each right-angle turn to facilitate cleaning. For steam pressures of 200 lb. or less, the water connection, if pipe is used, shall be of brass. [Either] The water column [or this connection] shall be fitted with a drain cock or drain valve with a suitable connection to the ashpit, or other safe point of waste, AND IF THE WATER CONNECTION THERETO HAS A RISING BEND OR POCKET WHICH CANNOT BE DRAINED BY MEANS OF THE WATER-COLUMN DRAIN, AN ADDITIONAL DRAIN SHALL BE PLACED ON THIS CONNECTION IN ORDER THAT IT MAY BE BLOWN OFF TO CLEAR ANY SEDIMENT FROM THE PIPE. The water-column blow-off pipe shall be at least $^3/_4$-in. PIPE SIZE. For steam pressures over 200 lb., the [water] connections shall be of steel pipe or tubing, wrought-iron pipe or [the equivalent] OF OTHER MATERIAL CAPABLE OF SAFELY WITHSTANDING THE TEMPERATURES CORRESPONDING TO THE MAXIMUM ALLOWABLE WORKING PRESSURE.

PAR. P-322 REVISED:

P-322 The steam connection to the water column of a horizontal-return tubular boiler shall be taken from the top of the shell or the upper part of the head; the water connection shall be taken from a point not less than 6 in. below the center line of the shell. FOR THE FIREBOX TYPES OF BOILERS, THE WATER CONNECTION TO THE WATER COLUMN SHALL BE TAKEN AT A POINT NOT LESS THAN 6 IN. BELOW THE LOWEST WATERLINE OR AS NEAR THERETO AS POSSIBLE, AND IN NO CASE LESS THAN 18 IN. ABOVE THE MUD RING.

PAR. P-323 REVISE FIRST SENTENCE TO READ:

P-323 Methods of Support. A horizontal-return tubular boiler over [78] 72 in. in diameter shall be supported from steel hangers by the outside-suspension type of setting, independent of the boiler side walls.

PAR. P-324 REVISED:

P-324 A horizontal-return tubular boiler, 14 ft. or more in length, or over 54 in. and up to and including [78] 72 in. in diameter, shall be supported by the outside-suspension type of setting, as specified in Par. P-323, or at four points by not less than eight steel or cast-iron lugs set in pairs. A horizontal-return tubular boiler up to and including 54 in. in diameter shall be supported by the outside-suspension type of setting as specified in Par. P-323, or by not less than two steel or cast-iron lugs on each side. THE DISTANCE GIRTHWISE OF THE BOILER FROM THE CENTERS OF THE BOTTOM RIVETS TO THE CENTERS OF THE TOP RIVETS ATTACHING THE HANGERS SHALL BE NOT LESS THAN THE SQUARE OF THE SHELL DIAMETER DIVIDED BY 675. If more than four lugs are used they shall be set in four pairs, the lugs of each pair to be spaced not over 2 in. apart and the load to be equalized between them (see Fig. P-20).

PAR. P-332 REVISE FOURTH SECTION TO READ:

Each boiler shall be stamped adjacent to the symbol as shown in Fig. P-22, with the following items WITH LETTERS AND FIGURES AT LEAST $^5/_{16}$ IN. HIGH with intervals of about one-half inch between the lines:

PAR. A-21*k* REVISED:

k In Edge Moor Boilers, Standard Type—in the bottom of the steam and water drum [24 in. from the center of the rear neck] NOT LESS THAN 6 IN. ABOVE THE BOTTOM OF THE DRUM, OVER THE FIRST PASS OF THE PRODUCTS OF COMBUSTION, and projecting through the sheet not less than 1 in.

PAR. A-21*q* REVISED:

q In Dry-Back Scotch Type Boilers—in the rear head, not less than 2 in. above the upper row of tubes, and projecting through the sheet not less than 1 in. WHEN THE DISTANCE BETWEEN THE UPPERMOST LINE OF TUBES AND THE TOP OF THE STEAM SPACE IS 13 IN. OR LESS, THE BOTTOM OF THE FUSIBLE PLUG MAY COME AT A LESSER DISTANCE THAN 2 IN. ABOVE THE UPPER ROW OF TUBES; BUT IN NO CASE SHALL THE PLUG BE LOCATED BELOW THE LEVEL OF THE TOP OF THE UPPERMOST ROW OF TUBES.

TABLE P-11 CHANGE THE DISCHARGE CAPACITY OF "198 LB." OF STEAM PER HOUR FOR $^3/_4$-IN. OUTLET AT 75 LB. GAGE PRESSURE TO "223 LB."

PAR. S-11 ADD NEW SECTION TO READ:

Bend Test for Universal or Edge-Rolled Plates when Permitted for Double-Strap Construction. *b* THE BEND-TEST SPECIMEN SHALL WITHSTAND BEING BENT COLD THROUGH 180 DEG. WITHOUT CRACKING ON THE OUTSIDE OF THE BENT PORTION AS FOLLOWS: FOR MATERIAL 1 IN. OR UNDER IN THICKNESS, AROUND A PIN THE DIAMETER OF WHICH IS EQUAL TO $1^1/_2$ TIMES THE THICKNESS OF THE SPECIMEN; AND FOR MATERIAL OVER 1 IN. IN THICKNESS, AROUND A PIN THE DIAMETER OF WHICH IS EQUAL TO 3 TIMES THE THICKNESS OF THE SPECIMEN.

PAR. H-1 REVISE SECTION *c* TO READ:

c For conditions exceeding those specified above, the rules for CONSTRUCTION AND SETTING OF power boilers shall apply.

PAR. H-14 ADD NEW SECTION TO READ:

b THE MINIMUM THICKNESS OF TUBES, IF OF COPPER, EITHER STRAIGHT, BENT, OR COILED, FOR USE IN WATER-TUBE OR FIRE-TUBE BOILERS, MEASURED BY BIRMINGHAM WIRE GAGE, SHALL BE AS FOLLOWS:

IN WATER BOILERS WHERE WORKING PRESSURES OF OVER 30 LB. AND NOT TO EXCEED 160 LB. PER SQ. IN. MAY BE USED:

$$t = \frac{D}{30} + 0.03$$

WHERE t = THICKNESS OF TUBE WALL IN INCHES, AND D = OUTSIDE DIAMETER OF TUBE IN INCHES.

FOR STEAM BOILERS TO BE USED AT PRESSURES NOT EXCEEDING 15 LB. PER SQ. IN., AND WATER BOILERS WHERE THE MAXIMUM ALLOWABLE WORKING PRESSURE DOES NOT EXCEED 30 LB. PER SQ. IN.:

$$t = \frac{D}{45} + 0.03$$

IN NO CASE SHALL A TUBE THINNER THAN NO. 16 GAGE (B. W. G.) BE USED.

PAR. H-21 REVISE THIRD ITEM ON PAGE 8 OF HEATING CODE TO READ:

C = 135 for stays screwed through plates and fitted with single nuts outside of plate, OR FOR STAYS WELDED INTO SUCH PLATES, PROVIDED THEY ARE SUPPORTED AT INTERVALS NOT EXCEEDING 5 FT.

PAR. H-31 REVISED:

H-31 Flanged Connections. Openings in boilers having flanged connections shall have the flanges conform to the American Standard given in Tables A-5 or A-6 of the Appendix to the Code, for the corresponding pipe size, and shall have the corresponding drilling for bolts or studs. OUTLET NOZZLES AND FLANGES IF OF STEEL CONSTRUCTION MAY BE RIVETED OR WELDED TO THE SHELL, BUT IF OF CAST-IRON CONSTRUCTION MUST BE RIVETED THERETO.

PARS. H-51 and H-104 REVISED:

H-51 [Every] EACH safety valve or water-relief valve SHALL [have] BE plainly [stamped on the body or cast thereon] MARKED BY THE MANUFACTURER in such a way that the markings [can] WILL not be obliterated in service, BY STAMPING OR CASTING ON THE CASING OR BODY OF THE VALVE, OR BY STAMPING OR CASTING ON A PLATE SECURELY FASTENED TO THE CASING, the letters A.S.M.E. Std., the manufacturer's name or trademark, and the pressure at which it is set to blow. The seats and disks of safety or water-relief valves shall be made of non-ferrous material.

PARS. H-53 and H-106 REVISE FIRST SECTION TO READ:

H-53 The minimum size of safety or water-relief valve or valves for each boiler shall be governed by the amount of the grate area as given in Tables H-6 or H-7. IN DETERMINING THE MINIMUM SIZE OF SAFETY OR WATER-RELIEF VALVES FOR DOUBLE-GRATE DOWN-DRAFT BOILERS, THE EFFECTIVE GRATE AREA SHALL BE TAKEN AS THE AREA OF THE UPPER GRATE PLUS ONE-EIGHTH OF THE AREA OF THE LOWER GRATE.

PAR. H-61 REVISED:

H-61 Water-Gage Glasses. Each steam boiler shall have at least one water-gage glass, THE LOWEST VISIBLE POINT OF WHICH SHALL NOT BE LOWER THAN THE LOCATION SPECIFIED IN PAR. H-64 FOR THE FUSIBLE PLUG.

PAR. H-64 REVISED:

H-64 Fusible Plugs. A fusible plug, if used, shall be placed at the lowest safe water line and in contact with the products of combustion. THE LOWEST SAFE WATER LINE IS THAT AT WHICH THE HEATING SURFACES OF A BOILER ARE EITHER COVERED OR ARE NOT EXPOSED TO PRODUCTS OF COMBUSTION UNTIL THESE PRODUCTS HAVE PASSED OVER NOT LESS THAN 75 PER CENT OF THE TOTAL HEATING SURFACE OF THE BOILER.

PAR. H-74 INCREASE SULPHUR REQUIREMENT IN LAST LINE FROM "0.04" TO "0.05" PER CENT.

PAR. U-6 REVISED:

FOR VESSELS IN WHICH PRESSURE IS NOT GENERATED BUT IS DERIVED FROM AN OUTSIDE SOURCE, each safety valve shall [have a full sized opening to the vessel. It shall] be so connected TO THE VESSEL, VESSELS OR SYSTEM WHICH IT PROTECTS SO as to prevent a RISE IN pressure BEYOND [in excess of] the MAXIMUM allowable pressure (see Par. U-2) [and so located that the contents of the vessel will not interfere with the operation of the safety valve] IN ANY VESSEL PROTECTED BY THE SAFETY VALVE.

FOR VESSELS IN WHICH PRESSURE MAY BE GENERATED, THE SAFETY VALVE OR VALVES MUST BE CONNECTED DIRECTLY TO THE VESSEL WHICH IS TO BE PROTECTED OR TO A PIPE LINE LEADING TO THE VESSEL; THE INTERNAL CROSS-SECTIONAL AREA OF THE PIPE LINE SHALL BE NOT LESS THAN THE NOMINAL AREA OF THE SAFETY VALVE OR VALVES USED, AND WITHOUT ANY INTERVENING VALVE BETWEEN THE VESSEL AND THE SAFETY VALVE OR VALVES PROTECTING IT. All vessels, the contents of which are likely to cause interference with the operation of a safety valve if attached directly to the vessel, shall have the safety valve or valves connected in such manner as to avoid such interference. When an escape pipe is used, it shall be full-sized and fitted with an open drain, to prevent liquid from lodging in the upper part of the safety valve, AND NO VALVE OF ANY DESCRIPTION SHALL BE PLACED [between the safety valve and the vessel nor] ON THE ESCAPE PIPE between the safety valve and the atmosphere. When an elbow is placed on an escape pipe, it shall be located close to the safety-valve outlet, or the escape pipe shall be securely anchored and supported. When two or more safety valves are placed on one connection, this connection shall have a cross-sectional area at least equal to the combined area of these safety valves.

PAR. U-17 REVISED:

U-17 For all pressure vessels the minimum thicknesses of shell plates, heads and dome plates after flanging shall be as follows:

When the Diameter of Shell is		
[14] 16 in. and under	Over [14] 16 in. to 24 in.	Over 24 in. to 36 in.,
1/8 in.	3/16 in.	1/4 in.
Over 36 in. to 54 in.,	Over 54 in. to 72 in.,	Over 72 in.
5/16 in.	3/8 in.	1/2 in.

except that for riveted construction the minimum thickness shall be 3/16 in.

PAR. U-28 REVISED:

U-28 On longitudinal joints, the distance from the centers of rivet holes to the edges of the plates, except rivet holes in the ends of butt straps, shall be not less than $1^1/_2$ and not more than $1^3/_4$ times the diameter of the rivet holes; this distance to be measured from the center of the rivet holes to [the top of] the calking edge of the plate before calking. The corresponding distance for circumferential seams shall be not less than $1^1/_4$ times the diameter of the rivet holes.

PAR. U-61 REVISED:

U-61 In laying out AND CUTTING the plates care must be taken to leave one of the stamps required in the Specifications for material used, so located as to be plainly visible when the vessel is completed; or in case these are unavoidably cut out, the heat number, quality of plate, minimum tensile strength and maker's name shall be accurately transferred as to form by the pressure-vessel manufacturer, to a location where these stamps will be visible. The form of stampings shall be such that it can be readily distinguished from the plate maker's stamping.

PAR. U-66 REVISE THE FIRST TWO SENTENCES TO READ:

U-66 Each such pressure vessel shall be marked in the presence of the inspector, A.S.M.E. Std. P. V., and with the manufacturer's name and serial number and working pressure. These markings shall be LEGIBLY stamped with letters and figures at least 5/16 in. high on some conspicuous portion of the vessel, preferably near a manhole, if any, or handhole, OR ON A NAME PLATE BRAZED OR OTHERWISE IRREMOVABLY ATTACHED TO THE SHELL PLATE.

PAR. U-84 REVISED:

U-84 FOR flanged heads dished CONCAVE TO PRESSURE, the depth of flange measured from a point tangent to the [corner] radius of the head to the end of the flange, shall not be less than 5 in. FOR HEADS DISHED CONVEX TO PRESSURE, THE DEPTH OF FLANGE SO MEASURED NEED NOT BE MORE THAN $2^1/_2$ IN.

PAR. U-112*a* INSERT THE HEADING "GRADE A" ABOVE PRESENT COLUMN OF CHEMICAL REQUIREMENTS, AND INSERT THE FOLLOWING COLUMN OF ADDITIONAL CHEMICAL REQUIREMENTS:

GRADE B
NOT OVER 0.20 PER CENT
NOT OVER 0.22 PER CENT
0.35 TO 0.60 PER CENT
NOT OVER 0.06 PER CENT
NOT OVER 0.04 PER CENT
NOT OVER 0.05 PER CENT

PAR. U-115 INSERT THE HEADING "GRADE A" ABOVE PRESENT COLUMN OF PHYSICAL REQUIREMENTS, AND INSERT THE FOLLOWING COLUMN OF ADDITIONAL PHYSICAL REQUIREMENTS:

GRADE B
50,000
0.5 TENS. STR.
27,000
27

PAR. U-122*a* REVISED:

U-122 Marking. a The name or brand of the manufacturer, melt or slab number, CLASS, and lowest tensile strength FOR THE GRADE specified in Par. U-115*a*, shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

PAR. U-126 REVISED:

U-126 The steel shall conform to the following requirements as to chemical composition:

Carbon	not over [0.24] 0.28 per cent
Manganese	not over 0.60 per cent
Phosphorus	not over 0.04 per cent
Sulphur	not over 0.05 per cent

PAR. M-1 REVISE LIMIT OF HEATING SURFACE TO READ:

20 sq. ft. [total] WATER heating surface.

PAR. M-2 REVISE FIRST SENTENCE TO READ:

M-2 Specifications are given in Pars. S-1 to S-213 of Section II of the Code, for the important materials used in the construction of boilers, and the materials for miniature boilers, for which specifications exist, shall conform thereto, except that STEEL PIPE FOR SIZES OVER 3 IN. IN DIAMETER SHALL BE OF OPEN-HEARTH STEEL. [in lieu of definite specifications for boiler-plate material, there may be used for the shells or drums of miniature boilers, seamless drawn shells with integral heads, or seamless or extra-heavy lapwelded steel or iron pipe or tubing, provided it is of open-hearth material and the weld is formed by the forging process.]

PAR. M-19 REVISE FIRST SECTION TO READ:

All boilers referred to in this section shall be plainly marked with the manufacturer's name, maximum allowable working pressure, which shall be indicated in arabic numerals, followed by the letters "lb.," and the serial number. All boilers built according to these rules shall be marked A.S.M.E. Std.—Miniature. THE SYMBOL AUTHORIZED FOR USE ON POWER BOILERS SHALL NOT BE USED ON MINIATURE BOILERS BUILT ACCORDING TO THESE RULES, NOR SHALL ANY ACCESSORY OR PART OF THE BOILER BE MARKED A.S.M.E. OR A.S.M.E. STD., UNLESS SO SPECIFIED IN THE CODE. Individual shop inspection is required for miniature boilers in the same manner as for power boilers.

Manufacturers' Data Report for Miniature Boilers. Revise item 3 in the Manufacturers' Data Report to read:

3. Type.....Boiler No. (.....)(.....)(.....)Yr. built
(Manufrs. Serial No.)(State and State No.)[(A.S.M.E. No.)]

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 520 to 522, inclusive, as formulated at the meeting of March 19, 1926, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 520

(Annulled)

CASE NO. 521

Inquiry: Is it to be understood from Par. U-59 of the Code that any fitting other than a nozzle is prohibited for all pipe connections over 3-in. pipe size? In other words, will not riveted or welded connections with threaded fittings be permissible under this section of the Code?

Reply: Par. U-59 requires flanged nozzles or fittings for all pipe openings over 3-in. pipe size when the maximum allowable working pressure exceeds 125 lb. per sq. in. It is the opinion of the Committee that this paragraph was not intended to limit the method of attachment of nozzles and outlet fittings to the shells of pressure vessels, provided they meet all of the requirements of the Code for Unfired Pressure Vessels.

CASE NO. 522

Inquiry: Is it permissible, under the requirements of Par. P-252 of the Code, to insert tubes into the thick-shell drums of high-pressure water-tube boilers by counterboring the tube holes on the inner face of the drum, as shown in Fig. 22, so as to form a narrow seat into which the tube end can be properly expanded?

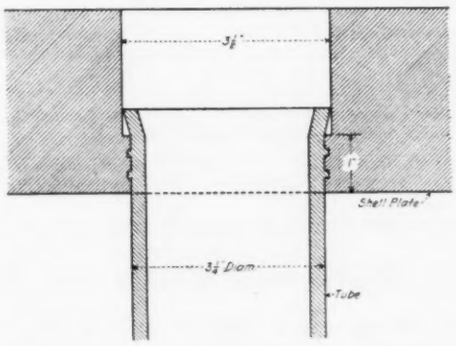

FIG. 22 NARROW TUBE SEAT FORMED BY COUNTERBORING INENR FACE OF DRUM

Reply: It is the opinion of the Committee that this method of forming the seats for the tube ends will meet the requirements of Par. P-252, provided the diameter of the counterbore is sufficiently greater than the diameter of the tube seat to permit of a proper amount of flare of the tube end.

Welded Joints

MY BELIEF is that the double-V type of weld is always superior to the single-V type. There is a strong tendency in any single-V weld, particularly when made with ordinary welding materials, to be imperfect at the bottom of the V. In addition to this, reinforcing the weld, that is, adding metal to one side, throws the line of resistance of the weld metal to one side of the line of application of the stress. This results, of course, in eccentric loading, and it is well known that this increases the stress at the bottom of the V to a very high point. It may be also pointed out that even if the weld be sound and entirely fused at the bottom of the V, there is a different amount of weld metal at the top of the V than at the bottom, and that the physical characteristics of a section at the top and bottom of the V are different because of the difference in characteristics between the base and weld metals. Further, my experience convinces me that the weld metal at the bottom of the V is never as good and as sound, even when thoroughly fused to the base metal, as it is in the upper part of the weld—so that as I stated before, I am thoroughly convinced that a weld of the double-V type is superior to one of the single-V type.

The average bursting strength of the regular tanks with double-V welds was 50,000-lb.—using a factor of safety of 5 or a working stress of 10,000 lb. and allowing 20 per cent for irregularities in workmanship gave the figure 8000 lb. It would certainly seem that this is not too high a figure for safety. (Extract from paper by S. W. Miller, presented before the American Welding Society and published in *Power*, May 11, 1926, p. 731.)

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

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By-Law: The Society shall not be responsible for statements or opinions advanced in papers or.....printed in its publications (B2, Par. 3).

The Secret of High Wages

DURING the past year American industry has entertained several British missions investigating the secret of high wages. The London *Daily Mail* sent to the United States, eight members of the engineering trade unions of England, and their conclusions as summarized by that journal are as follows:

There is a real spirit of fellowship among the employers and the employed in the United States

It is realized that high production means high wages

Employers are willing to take risks and to adopt every kind of labor-saving device.

All that is needed in Britain is good-will combined with a determination to pull together.

Another mission consisted of two young English engineers, Bertram Austin and W. Francis Lloyd, who came to this country late in 1925. These investigators in a book recently published appear greatly impressed with the fact that in the United States the factory is regarded as a productive machine and that every effort is made to increase the productive capacity per capita of labor by the development of time and trouble-saving devices. There is of course much more to the book than this, and it will bear careful study by engineers and manufacturers who are anxious to fully appreciate the basic purposes of industry.

American industrialists and engineers are too practical to believe that Utopia is here, an impression that might be gained from a cursory examination of the reports. Without much difficulty a recent anthracite coal strike can be recalled. Still more recently occurred the disorders in connection with the textile strike in Passaic. No, the millenium has not arrived.

Europe is turning to America for an explanation of American well-being and is requesting help in transplanting American methods into her industries. Voices are raised, protesting that even though America has learned how to produce cheaply and in quantity, her citizens have not learned to live any more happily than the people of Europe. The variables are too many and too complicated, and human experience with an industrial civilization is too short to permit the statement of laws by which methods may be transplanted from one environment to another without affecting the amount and scope of human happiness.

In general, however, American industry can be proud of the increasing coöperation with which its problems are attacked and solved. In that lies success and greater human happiness.

Public Recognition for Engineers

THE Dictionary of American Biography, to be published in the near future, will contain sketches of a goodly number of engineers. The editors are at present engaged in the selection of men not now living who are qualified for admission by their contributions to American civilization, and engineers will thus take their proper place among men of science, art, and affairs in this collection of the lives of American leaders.

Engineers will welcome the inclusion of outstanding engineers in the coming Dictionary as a well-earned recognition of the contribution made by the their profession to the development of this nation from a collection of agricultural communities into a complex unit of commerce and industry. Like all humans, the engineer appreciates well-deserved public recognition. He has failed to receive this, largely by force of circumstances, for he has no direct contact with the public which gains from the product of his skill and experience but is not informed of the exact part he plays in the development of the product. The biographical sketches of engineering leaders in the Dictionary will therefore be hailed by the rank and file of the profession not only as justice to the contributions of those leaders, but also as recognition for the entire profession. In this respect the Dictionary will reflect the modern view of history, in which emphasis is shifted from the soldier to the engineer and industrialist.

The engineering profession is woefully handicapped by its lack of a written record of the lives and accomplishments of its leaders. It suffers from the lack of inspiration that such records afford to the younger generation in the profession. Engineering biography is essentially engineering history, and the portion of the Dictionary devoted to engineers will therefore be gratefully received as an important contribution to a neglected portion of engineering literature.

International Contacts

DURING the month of April, New York had the good fortune to entertain a large number of foreign guests who were in this country to attend the meetings of the International Electrotechnical Commission and the International Standardization Association. Following the meetings in New York, the delegates visited a number of cities in the United States and Canada.

In the work of the International Electrotechnical Commission splendid beginnings were made in international codes for testing the various prime movers and electric machines, while in that of the International Standardization Association a skeleton organization was approved for a permanent coöperating standardization body.

On those who were able to attend some of these meetings and conferences and to meet the large group of guests, the splendid spirit of coöperation and the desire for mutual understanding that prevailed made a tremendous impression.

Throughout these meetings many opportunities presented themselves in which the delegates displayed a high sense of understanding of the greatest public good. These international contacts of technicians and engineers have always been fruitful of the coöperation which makes for peace.

Protecting the Public Against Quackery

IN THE May issue of Mechanical Engineering an account was given of the manner in which the engineering students of Brown University and the members of the Providence Engineering Society coöperated in a splendid opportunity for public service by exposing false statements made in the public advertisements of a device to increase the economy of household heaters. The means by which this exposure was completed was a series of tests according to the time-honored engineering method. This, of course, required proper laboratory apparatus and personnel, which were fortunately available.

An interesting development reported in China in the Tientsin *Times* shows how the idea has also appealed to the members of the Chinese Engineering Society. The British Boxer Indemnity Commission has been seeking suggestions as to the disposition of its Boxer indemnity fund. One of the proposals comes from the Chinese Engineering Society for the establishment of a testing laboratory and library. It is intended that the laboratory shall coöperate with manufacturers and engineers in studying and improving engineering and industrial methods, and also test products submitted by manufacturing concerns and issue certificates of quality if the products are found satisfactory.

This statement of purpose is in direct accord with the desire of the engineering profession to protect, in so far as possible, the public against quacks and nostrums that are submitted for sale. The Chinese Engineering Society finds the laboratory an essential. In this country many laboratories and the needed personnel are available. All that is required in this country is the organization of the suitable public-spirited group in the local engineering societies.

The American Medical Society has found it possible to be of direct service to the public and to the medical profession in its study of quacks and cure-alls. The engineering profession has a like responsibility, which is increasing in importance as the devices and machines that are presented for public consumption and use increase in complexity and number.

A Machine-Tool Section for the Museum of the Peaceful Arts

THE splendid bequest of the late Henry R. Towne for a Museum of the Peaceful Arts is known to most of the members of the Society. The importance and value which he placed upon his purpose and upon the great public benefit to be derived from it are shown in his will, where he says that while the United States is the greatest industrial nation in the world, while its inventors have won foremost place in every field, and its organized industries excel those of all other countries, these great achievements are unrepresented by adequate collections similar to the magnificent museums of Fine Arts and of Natural History; and that there should be a permanent exposition of American achievements in the Peaceful Arts which should include "the arts of agriculture and animal industry, of forestry and woodworking, of mining and metallurgy, of transportation and communication, of engineering and architecture, of industrial chemistry, of electrical mechanisms, of aeronautics, of metal, textile and building trades, and of the innumerable subdivisions of all of these, including their products, processes, and implements."

He expresses the hope that his bequest might initiate a movement to provide such a museum and become the nucleus of a great endowment to which public-spirited citizens might contribute as long as the industrial arts flourish in this country.

He further says that while the project outlined should be planned from the beginning for a development adequate to its great purpose, it must of necessity begin on a basis adjusted to its available funds. He therefore suggests that, as the most fitting industry, the first unit be devoted "to machine tools, an industry in which this country is the acknowledged leader, for these constitute a chief part of the equipment of many other industries and are the means whereby all the equipment of all other industries are produced."

Following this wise suggestion, the trustees of the Museum of the Peaceful Arts are organizing such a section. Since a museum must be more than a mere aimless collection of historical material brought together without method or system, it is desirable that there be a definite and well-developed plan; and all exhibits should conform to this plan in order to bring out their relative importance and historical sequence.

The plan for the Machine-Tool Section is being developed, and a general outline of it is given herewith. As it now stands, the field is covered in three divisions as follows:

DIVISION I—ELEMENTS OF MACHINES AND MACHINE-SHOP PRACTICE

Machine tools are largely combinations of a few standard elements, some of which appear in many types of machines. Each element has a technique of its own, and a history which can be shown from primitive forms down to the latest practice.

Class

1 *Hand Tools*
Primitive implements, machinists tools, carpenter's tools

2 *Cutters*
Steels used, single-edged lathe-planer types, milling cutters, drills, reamers, forming tools, woodworking tools, etc.

3 *Grinding*
Flat and rotary, soft-stone, hard, disk, buffing, polishing, etc.

4 *Slide Rests*
Evolution and modifications, turret principle

5 *Chucks, Clamping Devices*
General principles of jigs and fixtures

6 *Screws*
Types of thread, with their uses, methods of making, taps, dies, lead screws, milling, etc.

7 *Gears*
Early types, tooth forms, spurs, bevels, worms, etc.

8 *Cams*
Different types with their uses

9 *Power Transmission*
Shafting, hangers; plain, self-oiling, and roller bearings; pulleys, clutches, etc.

10 *Hoists and Cranes*

11 *Measuring*
Scales and end measurements, micrometers, verniers; limit, profile, position, dial gages, etc.; optical methods

12 *Methods of Generating Surfaces*
With examples of application.

DIVISION II—MACHINE TOOLS AND STANDARD PRODUCTION MACHINERY

Grouped by major types. History of each type to be shown from primitive forms through the significant stage to the latest forms. The kind of work for which each type is adapted to be brought out, with the reasons therefor.

Class

1 Lathes
2 Boring Mills and Boring Machines
3 Planers, Shapers, Slotters, Rifling Machines
4 Milling Machinery
5 Drilling Machinery
6 Broaching Machines
7 Grinding Machinery
8 Gear-Cutting Machinery
Formed-tooth, templet, generating, hobbing, etc., for spur, bevel, and worm gearing.
9 Presses, stamping and cold-drawing machines; Punches and Shears, rolling, bending
10 Forging Machinery
Steam and power hammers, drops and die forging, hot rolling, swaging, extrusion, wire drawing, etc.
11 Foundry Equipment and Methods
Patterns, furnaces, molding machines, cleaning, etc.
12 Heat Treatments, Hardening, Tempering, Pyrometry
13 Welding Equipment and methods, Flame Cutting, Brazing, Soldering, etc.
14 Woodworking Machinery
15 Certain special classes, as pin, needle, ball, tack, and watch machinery.

DIVISION III—OLD SHOPS

Showing workmen engaged in the operations and using the tools typical of periods chosen. All the details as to kind of product being worked upon, lighting, benches, shafting, etc., to be characteristic of the periods.

1776—Hand-Tools Era
Whip lathes, post drill, forge, small cupola, house hardware, agricultural tools, kitchenware.
1800—Beginnings of Specialization
Templets, filing jigs, head-stock lathe, candles.
1820—Milling machine, drills, gages, Blanchard lathe, back-geared lathe, candles or whale-oil lamps.
1840—Planer, shaper, jigs, lead-screw lathes, kerosene lamps
1860—Colt and Robins and Lawrence Shops, Lincoln millers, hand turret lathe—gas lighted
1880—Automatic lathes, etc.
Gas lighted
1900—Multi-spindle lathe, etc.
1920—Broaching, precision grinding
Motor-driven tools and enclosed gearing.

The various classes above are further subdivided into groups, not given here, as for instance, Lathes, into primitive forms, the evolution of the engine lathe, turret lathes, multi-spindle lathes, automatics, etc. The whole outline is tentative and open to improvement either through substitution or addition.

Suggestions which might help in the development and realization of this plan are earnestly invited. Any information as to old tools and shops, anywhere throughout the country, particularly

hand tools and primitive shop equipment, old pictures, original drawings, and descriptions or photographs which will help in reproducing the old shops, will be of great assistance. Authentic accounts of the shop practices and daily life of old timers will help greatly in reproducing the atmosphere. Of equal or even greater value than the suggestions outlined above will be the contribution of originals or information regarding available originals which could form a part of this collection which promises to be unique in the world.

Any one who can help in connection with any of the three divisions outlined above is requested to communicate with the Museum of the Peaceful Arts, 29 West 39th Street, New York City.

JOSEPH W. ROE.[1]

The Polar Flights

IT IS NOT always the goal itself that is of as much value in engineering as the ability to reach it. After all, no sane person wants to drive in an automobile at a speed above, say, 50 miles, and no one whether sane or not should be permitted to do so. Yet racing in which speeds in excess of 150 miles are in sight has attracted a large amount of attention in technical circles and has been of great help in the development of the industry, not only because it has helped to sell the superspeed cars, but because the ability to build cars capable of withstanding the terrific speed of $2^1/_2$ miles a minute implies also the ability to build commercial cars of light weight, great strength, and ample reserves of power.

The same ideas apply largely to the recent endeavors to reach the Pole by air. There is no longer the lure of getting there first; Admiral Peary settled that. There is, however, the great attraction of showing that aircraft can do it, and in proving that this new method of locomotion can achieve something with ease and rapidity which was previously done only at immense sacrifice in time and toil.

Neither the *Josephine Ward* of Commander Byrd nor the *Norge* of Amundsen and Ellsworth are notable for their comfort in flying. But when we compare the conditions under which the modern adventurers reached the "top of the world" with the scarcely credible hardships of even the best-equipped previous expeditions such as Nansen's and Peary's, the enormous progress due to the development of flying becomes obvious. The Byrd flight is notable from the point of view that it required for its success not only excellent operation of the machinery and a super-daring and the highest degree of skill of the flying personnel, but also a very unusual degree of preparation and teamwork in overcoming the tremendous difficulties of such an undertaking. In view of the many gloomy comments on the state of aviation in the United States, it is of interest to note that to the numerous officially homologated flying records held by the United States there has been added one of such prominence that it need not even be homologated: namely, King's Bay to the North Pole and back under the Stars and Stripes.

The Rotorship and Its Possibilities

THE arrival of the rotorship *Baden-Baden* in New York on May 10 calls attention again to this interesting attempt to provide a new form of power generation. As previously described, the inventor, Anton Flettner, makes use of the so-called Magnus effect, in accordance with which the pressure of the wind on a rotating cylinder is greater on one side than on the other, and tends to move the cylinder in the direction of the lower pressure. The *Baden-Baden* is equipped with two sheet-aluminum rotors 45 ft. high, driven by electric motors at an average rate of 100 r.p.m. In addition to this it is equipped with a Diesel engine of 160 hp. that serves as auxiliary power.

The vessel left Kiel on March 31, reached Las Palmas on April 14, and New York on May 10. It is stated that in the 25 days from April 14 she voyaged 3840 sea miles, of which 200 were covered by the rotors alone; the rest of the distance she used her water screw as well. It would appear, therefore, that the demonstration made is by no means conclusive. That rotors do afford a means of propulsion is unquestionable, but whether this means of propulsion is sufficiently economical to compete with other existing methods—sails on one hand, and heat power as represented by steam or oil on the other—is a matter on which a large amount of additional information will be necessary.

The development is of considerable interest from another point of view. Because of the universal rise in fuel costs there has been a quite perceptible revival of interest in wind motors—not the picturesque windmill which can be seen in Dutch landscape views, but the more modern and efficient types. The study of the aerodynamics of the air propeller, together with the facilities for testing air machinery provided by the wind tunnel and its appurtenances, have supplied a vast amount of new information on the action of wind motors and have made it possible to work out designs which even today seem to be capable of competing with steam in places where limited amounts of power are required and where local coal is not available. This applies particularly to certain colonies in Africa and Australasia. The Flettner towers are but one of these developments, and improvements have already been proposed that work on essentially the same principle—that of utilizing the Magnus effect. Among these may be mentioned, for example, the Savonius rotors which were described in MECHANICAL ENGINEERING, Nov., 1925, p. 911, and there is no question but that other developments will follow if and as soon as it is established that this principle can be economically employed, even if only under a combination of certain special conditions.

Both in the technical and in the popular press there has been some misunderstanding as to the true aim of the installation of rotors on rotorships. It would appear from statements made by the inventor that there is really no intention of replacing sails by rotors. The true aim is to utilize the power of wind as an auxiliary to the screw and to use a motor like a Diesel as the main propelling force. A certain amount of this power is to be diverted, however, from the screw to the rotors, with the result that by this combination about 20 per cent of the fuel can be saved. This of course puts quite a different complexion on the whole problem. It is claimed that the man power necessary to operate the rotors on a power-engined vessel is very small and that the additional complications in service and extra cost of installation entailed by their use are small as compared with the savings in fuel resulting from the use of the wind as an auxiliary propelling power.

It is not quite clear, however, how the rotors may be used for stationary plants. In the Magnus effect the rotating cylinder tends to move on the wind. If the cylinder is installed on a ship it is easy to see how this can be utilized to move the ship attached to it. But how the same thing can be done usefully in a stationary plant is not at all clear as yet. Attention may be called in this connection to the fact that considerable work has been already done by others in England and Holland in the matter of applying the Magnus effect to airplanes.

Second Annual Meeting of American Refractories Institute

THE second annual meeting of the American Refractories Institute was held on May 12 at the Bellevue-Stratford Hotel in Philadelphia. The Institute consists of individual members and representatives of industrial concerns, both on the manufacturer's and on the consumer's sides. The Institute has effected an arrangement under which research is being carried on at the Mellon Institute in Pittsburgh. Testing of products for members is being done at the same place at cost. Data of research of the Institute are in part made generally available and in part covered by patents. Because of these latter features the Institute does not publish current data of investigations, but reserves the information obtained until such time as it can be released without affecting the patent situation.

Dr. E. R. Weidlein, Director of the Mellon Institute of Research, made the first address, in which he pointed out that if the refractories industry wanted science to get results for it, it would have to give the research workers time to obtain the results, and also pay for them. He cited a report of the U. S. Chamber of Commerce on the value of scientific research to industries and the utilization of this research by industries. From this report it would appear that some

[1] Professor of Industrial Engineering, New York University; Staff Consultant of Museum of the Peaceful Arts. Mem. A.S.M.E.

industries as, for example, the electrical, utilized science 100 per cent. Others utilized it a good deal less, e.g., the steel industry, 50 per cent, while the ceramic industry tagged at the end with 12 per cent. Papers presented at the Institute meeting would indicate that this condition is now realized and is being rapidly corrected.

MULLITE REFRACTORIES

Mullite refractories formed the subject of a paper by M. L. Freed, Research Fellow of the U. S. Bureau of Standards, Washington, D. C. At certain high temperatures (a little above 1500 deg. cent.) he said, kyanite, sillimanite, and andalusite broke down into a glassy silicate and a material of complicated structure which had been given the name of "mullite." Some deposits of minerals capable of producing refractories of the mullite type had been known for a considerable time, but in the past none of these deposits had been sufficiently extensive to be of general interest. The situation had changed recently with the discovery of ample kyanite deposits in India. At the Bureau of Standards extensive tests had been carried out on bricks made of kyanite alone or with clay and alumina, and mullite alone or with clay and alumina, and while some of these bricks had not shown any special excellence, others had given most impressive results. Thus mullite bricks had stood up under a compression of 50 lb. per sq. in. at temperatures of the order of 1400 deg., which was a very real achievement. In spalling tests some of the bricks had been unaffected after a repetition of more than 60 cycles of the standard Bureau of Standards test consisting of heating the brick at the entrance to the furnace to 1450 deg., immersing it in running water at half its length for 3 min., letting it steam for 5 min., and returning it to the entrance to the furnace for another heating.

In the discussion which followed a representative of the Champion Porcelain Co. stated that the addition of sillimanite to porcelain increased the mechanical strength of the latter $3^1/_2$ times. In the manufacture of spark-plug porcelains, natural sillimanite was used in preference to purified materials, because it had been found that the impurities present in the natural mineral were beneficial to that particular grade of porcelain.

TESTS OF FIREBRICK FOR SPALLING

S. M. Phelps, Refractories Fellow, Mellon Institute, described the study and development of tests for firebrick with special reference to spalling.

In the work of the Mellon Institute, he said, an extensive series of load tests had been carried out in a special furnace which permitted handling 10 bricks at a time with the same ease with which two bricks could be handled before (the furnace is heated by the surface-combustion process). Load tests had been carried out at temperatures of 1200, 1350, and 1450 deg. cent., and with compressions of 10, 25, and 40 lb. per sq. in. From these tests the general conclusion had been reached that the action of temperature was far more important as an indicator of quality of brick than variations in compression.

Thereafter another series of tests had been conducted in which bricks were made up into columns 9 in. square and tested at 1450 deg. cent. for seven hours under 25 lb. pressure. At first one of these columns had been placed completely into the furnace and acted on by the heat on all sides. Next an attempt had been made to approach service conditions in the test. With this in view the same column had been heated in a special furnace on one surface only and protected on the other side by a 9-in. layer of insulation. While in the previous test made with the heat all around the column a compression of 22 per cent had been obtained, there had been zero compression with the same brick in the second test, which would indicate that the standard load test did not give a reliable index as to the probable behavior of a brick in service.

The most important tests had dealt with the subject of spalling (breaking up of a brick under the action of heat and service strains). Forty brands of brick had been tested under the standard A.S.T.M. test (4-in. water immersion after heating to 1450 deg. cent.), under a special Government test, and under a test worked out by the Refractories Institute Research Committee and consisting of heating to 1350 deg. and 2-in. immersion. This latter test had given the most uniform results and was said to approach most nearly service conditions. It was recommended to the attention of the proper committees of the A.S.T.M. by the Research Committee of the Institute.

Next, a special furnace had been built for spalling tests. This furnace consisted of two chambers, one of which was heated and the other might be supplied with air blast for cooling. The bricks were held in a device somewhat resembling the common scales with an upright in the middle and arms to one side. These arms contained a panel of 20 bricks; each panel was first held over the heated chamber and then swung around and brought to rest on the top of the cooling chamber, the mechanism for swinging the arms being operated automatically.

A study had been made with regard to the time and temperature at which bricks became affected. When brick had been used "as received" it had been found it would not spall appreciably with regard to thermal shock. Because of this the bricks had first been held for 7 hr. at 1550 deg. cent., which had produced a vitrification on the surface similar to that in service. It had been found in producing this vitrification that the matter of temperature played a more important part than did that of time. This preliminary treatment had been followed by the spalling treatment consisting of 10 cycles, each of 10 min. of heating to 1450 deg. cent., followed by 10 min. of cooling in an air blast. This method of testing had proved capable of revealing facts which other tests did not show at all, and, among other things, had given for the first time a satisfactory method of investigation for silica bricks. In all work at the Mellon Institute the softening point of the brick was considered instead of the fusion point.

EXPANSION OF REFRACTORY BRICKS

The refractories industry in New Jersey formed the subject of a paper by G. H. Brown, head of the ceramics department, Rutgers University, New Brunswick, N. J. In the course of this investigation bricks made of various kinds of materials had been tested for expansion. Bricks of the kaolin type had shown on the whole a uniform course of expansion with comparatively low totals. Quartz-type bricks, on the other hand, had shown a very much greater total expansion with a less regular procedure, which was explained, of course, by the change at certain temperatures of quartz to cristobalite, this change being accompanied by an appreciable increase in volume.

A very interesting fact indicated by the paper is that in siliceous bricks above 650 deg. cent., the expansion is practically nil, the curve rising rapidly and smoothly at first, then forming a kink or bellying out at the quartz-cristobalite conversion range, then proceeding upward for a little while longer, and at about 650 deg. cent., practically flattening out. In fireclay brick the expansion goes on increasing with the temperatures; in magnesite brick this expansion is fairly uniform and very high indeed.

In the discussion which followed it was brought out that if used intermittently at high and very low temperatures, siliceous brick will spall more than fireclay brick. If the brick is to be heated to high temperatures and then cooled without reaching temperatures, say, below 900 deg. cent., there will be a good deal less of spalling with siliceous brick than with fireclay brick, the above-described process of expansion of the two probably accounting for this behavior.

The other papers presented were—Service Conditions in Open-Hearth Furnaces as Affecting the Life of Refractories, by F. W. Schroeder, Assistant Chemist, U. S. Bureau of Mines, Pittsburgh, and Permeability as a Measure of the Uniformity of Firebrick, by Dr. A. E. R. Westman, Research Fellow, University of Illinois, Urbana, Ill.

Erratum

IN THE abstract from *Engineering* describing the 50,000-kw. Parsons turbo-alternator for Chicago, published in the May, 1926, issue of MECHANICAL ENGINEERING, it was stated that the builders' estimates of this turbine are based on steam being supplied at the stop valve at a temperature of 750 deg. cent., and the steam withdrawn for reheating at a temperature of about 425 deg. cent. In both of these cases the temperatures should be in degrees fahrenheit instead of degrees centigrade.

The Alden Hydraulic Laboratory Enlarged

Trustees of Worcester Polytechnic Institute Formally Open New Laboratory at Chaffins, Mass.

ON FRIDAY, May 7, a large group of hydraulic engineers, many of them graduates of the Worcester Polytechnic Institute, and others connected with the hydraulic departments of engineering colleges and power companies, assembled in the village of Chaffins, Mass., a suburb of Worcester, to participate in the opening of the enlarged Alden Hydraulic Laboratory. For some years this laboratory has been in operation on its present site but recently Mr. George I. Alden gave the necessary funds to enlarge and reëquip it.

Accordingly, the trustees of the Institute set Friday, May 7, as the day for its formal opening. On that occasion the entire plant was in full operation, illustrating the various methods of water measurement, dam, spillway and intake model testing, and many other hydraulic experiments. No formal exercises were scheduled, but the entire time, except for luncheon, was devoted to an inspection of the plant. As a result a good opportunity for group discussion, the exchange of ideas and experiences, and the meeting of engineers interested in the hydraulic design and testing was provided by this very enjoyable occasion.

Prof. Charles M. Allen, now in charge of the Hydraulic Department of W.P.I., was master of ceremonies and made an ideal host. Mr. Alden, the donor of the laboratory, was present part of the day. Dr. Ira Nelson Hollis, president of the Institute until 1926, was also present to welcome the guests and the "old grads." Most of the visitors reached the laboratory shortly after ten o'clock in the morning, and did not leave until after four in the afternoon. A buffet luncheon was served by the trustees of the Institute.

The Alden Hydraulic Laboratory is situated five miles north of the Institute. It is readily accessible by electric cars, automobiles, bus lines, and steam railroad.

GROUP PRESENT AT OPENING OF LABORATORY, SHOWING GEORGE I. ALDEN, THE DONOR (SEATED), AND PROF. C. M. ALLEN (DIRECTLY BACK OF MR. ALDEN)

The site, formerly occupied by a woolen mill, was discovered in 1894 by Professor Alden, then head of the mechanical engineering department of the Institute. Through the generosity of the president of the Board of Trustees, the Hon. Stephen Salisbury, it was presented to the Institute. Another member of the corporation, Charles H. Morgan, had the plans drawn, and was instrumental in obtaining the first piece of apparatus installed, the 36-in. venturi meter which had been used at the World's Fair Grounds in Chicago in 1893. Elbert H. Carroll, a member of the class of 1890, superintended the construction of the first laboratory.

In 1910 Professor Alden gave money to build the original low-head laboratory, which was put upon the site of an old grist mill on the other side of the road from the main laboratory. Two additions have been made to this building from income derived from commercial testing.

In 1924 foundations were built surrounding the original main laboratory, and early in 1925 the present building was completed. Mr. Alden, now a member of the Board of Trustees, gave the money for this new laboratory. Through his generosity, greatly enlarged facilities have been provided for instruction in hydraulic engineering, for research work, and for commercial testing.

FLOWAGE RIGHTS

The Institute owns the flowage rights on three ponds. The upper, or No. 1, contains about 200 acres, and is used for storage. This pond discharges through two head gates into pond No. 2, which has an area of about four acres. From this pond a 40-in. steel riveted pipe about 400 ft. long takes the water to the main laboratory under a head of about 30 ft. The overflow from this pond empties into pond No. 3, which has an area of about two acres, and supplies water to the low-head laboratory under a head of about 15 ft.

BUILDINGS

The main laboratory is a wooden building 110 ft. long by 45 ft. wide and 15 ft. high. It is of mill-type construction and thoroughly insulated on the walls and underside of the roof with a material $\frac{1}{2}$ in. thick, made of paper pulp. This insulation has made possible a great saving in fuel during the past winter.

The low-head laboratory is a wooden building 70 ft. long and 15 ft. high. Its width is 36 ft. for about one-half its length and 24 ft. for the other half. It is insulated in the same manner as the main building. A portion of it is used for a machine and repair shop.

The total floor space of all buildings, including office, storehouses, and structures housing the river-gaging apparatus and pitot-tube and current-meter rating station, is approximately 19,000 sq. ft.

EQUIPMENT

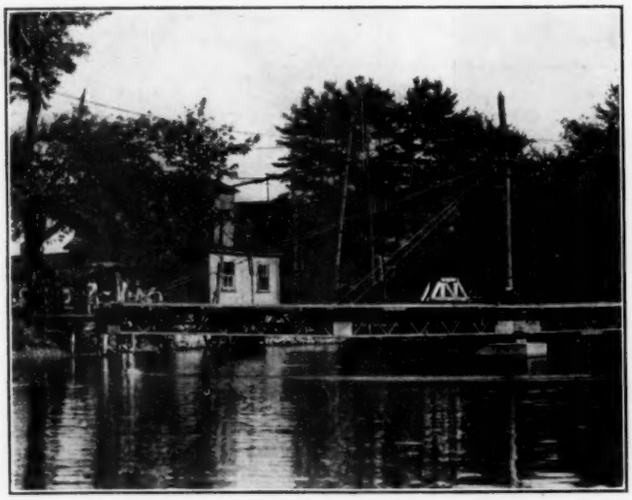
There is about 400 ft. of 40-in. pipe from pond No. 2 to the main laboratory. This pipe has furnished means for a variety of experiments, such as the determination of friction of flow, measurement of flow by pitot tubes and pitometers, and measuring the flow by the salt velocity method. As a matter of interest, it was on this pipe line that the first experiments with the salt velocity method were made. This method is today considered one of the standard methods.

A differential surge tank designed by R. D. Johnson of New York is located just inside the building and is adapted for experimental investigations. The money for this installation was given by George I. Rockwood, of the class of 1888.

The water then passes through the 36-in. venturi meter, then through a Dow valve, designed by E. A. Dow, of the New England Power Company, built by the S. Morgan Smith Co. of York, Pa., and given to the laboratory for experimental purposes. It then goes to two wheels, an 18-in. Hercules and a 15-in. Platt (both of which can be tested for power and efficiency by the use of Alden absorption dynamometers), and a 10-ft. standard weir, the latter situated at the farther end of the weir flume in the basement. Current-meter tests are carried on in this flume.

A 12-in. and a 6-in. pipe line branch off from the main line just above the venturi meter. The 12-in. line supplies water to a 12-in. venturi located on the west wall of the building, and discharges into a wasteway, over the standard weir, or into a 50,000-lb. weighing tank.

The 6-in. line runs to an experimental tank and a weighing tank located in the west bay, and can be used for a variety of experiments. Both laboratory buildings are supplied by a 6-in. town water pipe under a pressure of 135 lb. per sq. in.



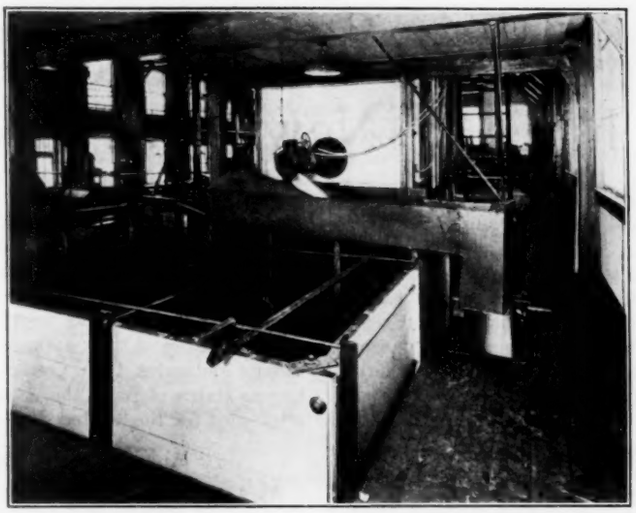
CURRENT-METER RATING STATION

VIEW SHOWING MAIN LABORATORY AND LOW-HEAD LABORATORY

The weighing tank, 10 by 12 by 6 ft., is copper-lined, and is mounted on Fairbanks scales.

Pumps of various kinds, sizes, and makes are easily tested here for capacity and efficiency, using the weighing tank for accurately determining the discharge. C. L. Newcomb, of the class of 1880, has presented several Deane pumps to the Laboratory, and the Gould Pump Company has furnished centrifugal and power pumps. The Buffalo Forge Company, through C. A. Booth, another alumnus (1898), has given centrifugal pumps.

A concrete dam and weirs, in the wasteway in front of the main laboratory, control and measure the flow, and a concrete flume along the side carries water to a distributing forebay. An overshot waterwheel is supplied from this forebay, and there is an opening left on one side for future extensions.



INTAKE MODEL AND WEIGHING TANKS

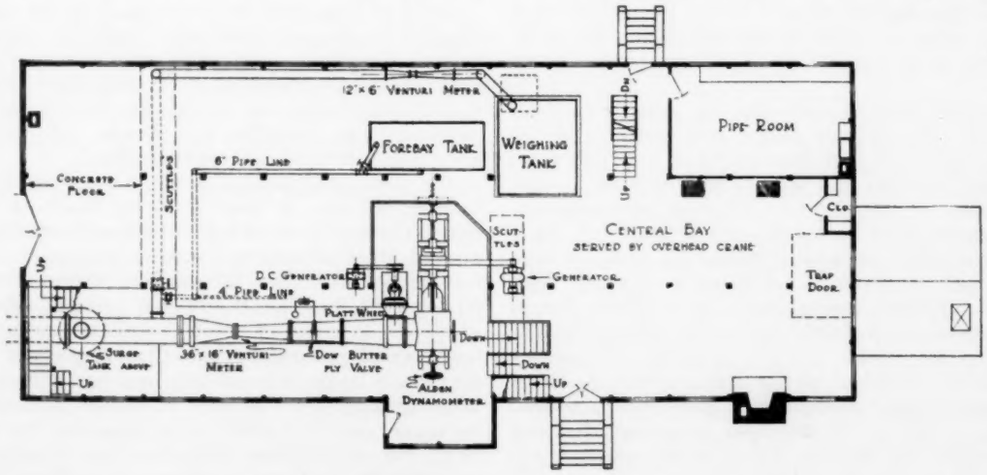
In the low-head laboratory there is a copper-lined pressure wheel case, where model wheels and draft tubes are tested. It was in this laboratory that a long series of comparative draft-tube tests were made for the Alabama Power Company. Tests have also been made there for the Laurentide Power Company, Ltd., of Grand Mere, P. Q., the William Cramp & Sons Ship and Engine Building Company, of Philadelphia, and the Wellman-Seaver-Morgan Company of Cleveland.

The current-meter and pitot-tube rating station located on a large rock in pond No. 2 is operated by means of water-wheel gear and rope drive. The boom is 84 ft. in diameter, is mounted on ball bearings, and the ends can be turned at any speed up to 20 ft. per sec.

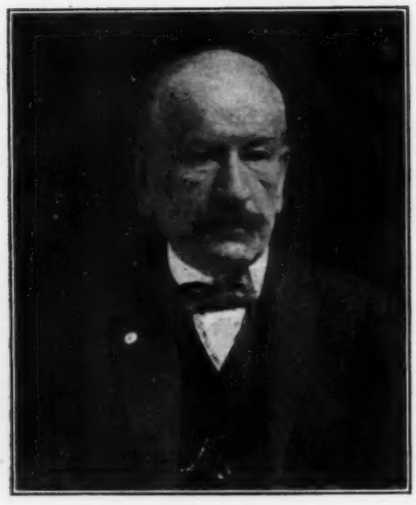
Special pitometers have been rated here for use on ocean liners as logs, and the station was used during the war by Maj. V. E. Edwards, of the class of 1888, to determine the friction of various types of shells through water.

The Morgan Construction Company, through Paul B. Morgan, class of 1890, gave the laboratory several d.c. motors and generators, which are proving very useful. Many other individuals have contributed both apparatus and funds to the laboratory. As a matter of fact, whenever tests are made on apparatus that proves to be satisfactory, it seldom leaves the laboratory, and in this way a large part of the equipment has been obtained. Much of this apparatus has been set up and tested by students in connection with their thesis work.

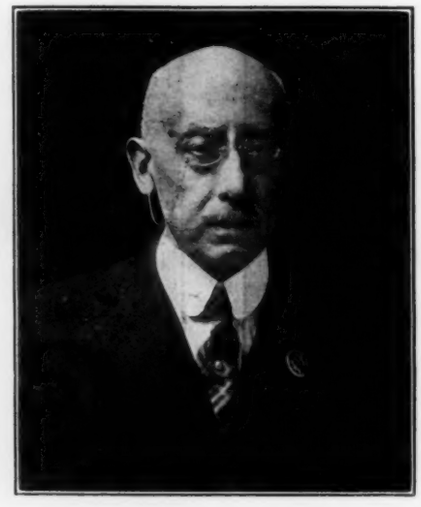
The section of land on the river below the laboratories affords ample opportunities for the study and design of various hydraulic developments. The Worcester Polytechnic Institute considers itself fortunate in having a hydraulic laboratory covering so much territory and with so great a variety of opportunities for testing of all kinds. Several groups of students can perform laboratory experiments without conflict. Ample room for thesis and post-graduate work is available.



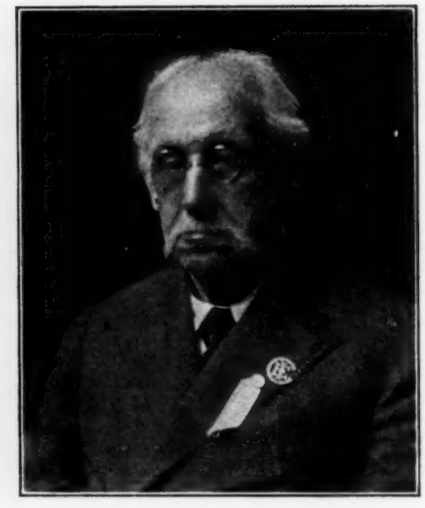
FIRST-FLOOR PLAN OF ALDEN HYDRAULIC LABORATORY



DR. C. O. MAILLOUX, E.E.,
Honorary President, I.E.C.



DR. GUIDO SEMENZA,
President, I.E.C.



COL. R. E. CROMPTON, C.B.R.E.,
Honorary Secretary, I.E.C.

The International Electrotechnical Commission Concludes Its New York Meeting

ON THURSDAY, April 22, the hundred delegates of the International Electrotechnical Commission and Third International Standardization Conference concluded their very busy ten days in New York and set out upon an equally busy period of visits to the principal industrial centers in the eastern United States and Canada. Their New York meeting was successful in every way, and not only was a great deal of valuable work accomplished in international standardization of engineering nomenclature and engineering elements, but also great good was done in the promotion of international good-will.

The official welcome to the delegates was described in the May issue of MECHANICAL ENGINEERING. In addition to that event two others of a somewhat similar nature deserve mention. The first is the luncheon to the delegates held at the Commodore Hotel on Wednesday, April 14. A large audience attended and John W. Lieb, the toastmaster, opened the speaking program by outlining the development of standardization in the electrical field. Dr. Michael Pupin gave a very interesting talk illustrated by incidents from his own boyhood in a small Serbian village, and punctuated by flashes of humor. He urged the need of neighborliness among nations. Sir Archibald Denny, of Dumbarton, Scotland, told of the British plan of one standardization agency for all industries, which is functioning satisfactorily. President Guido Semenza pledged the full support of the I.E.C. to such a standardization program as detailed by Sir Archibald. The other speakers at this luncheon were Dr. C. H. Sharp and Dr. C. O. Mailloux.

On Monday evening, April 19, a banquet was held for the delegates at the Hotel Astor. Gano Dunn, past-president of the A.I.E.E., presided, and James J. Walker, Mayor of New York City, addressed the large gathering and warmly welcomed the foreign delegates in the name of the city. At this time representatives of the different nations spoke upon the work of the I.E.C. as it applied to their particular problems. Among the speakers were Dr. Semenza, of Italy; E. Uytborck, of Belgium; Professor Feldmann, of Holland; Domingo Santa Maria, of Chile; E. Huber-Stockar, of Switzerland; Sir Richard Glazebrook, of Great Britain; and John W. Lieb, of New York. At the conclusion of this meeting Prof. Luigi Lombardi, president of the Italian Electrotechnical Committee, extended a hearty invitation to the scientists to hold their next meeting in Rome. It was later announced that this invitation was accepted and that the I.E.C. would gather in the Italian capital during the summer of 1927.

On Wednesday, April 21, upon the eve of their departure, the foreign delegates delightfully entertained their American hosts, also at the Astor. Dr. Guido Semenza presided and began his remarks by highly complimenting Messrs. Lieb, Smith, and Sharp, as well as their many associates of the United States National Committee, upon their hospitality and the efficient manner in which they had planned and managed the entire convention. As a material token of their appreciation Dr. Semenza, on behalf of the foreign delegates then presented to the Committee a beautiful bronze statue of Nike, the winged Goddess of Victory. Dr. Sharp responded for the United States Committee.

ADVISORY COMMITTEES PRESENT REPORTS

At the plenary and technical meetings of the I.E.C. the ten advisory committees reported their progress in the study of the following subjects: Nomenclature; Rating of Electrical Machinery; Symbols; Prime Movers, both hydraulic and steam; Resistance of Aluminum; Lamp Caps and Holders; Voltages for Distribution Systems; Test Voltages for Apparatus; Traction Motors; Insulating Oils; and Rules and Regulations for Transmission Lines. So many countries are involved in these considerations that no decision of an Advisory Committee is submitted to the Plenary Meeting for ratification until the National Committees have had an opportunity of instructing their delegates.

As far as Nomenclature is concerned, it was recommended at the Plenary Meeting on Wednesday, April 21, that the Committee actively continue its work of bringing all countries into agreement upon the precise meaning of electrical words and phrases. The new British glossary was recommended as a basis for building comparisons. Five countries had already submitted their national vocabularies in either French or English.

The Committee reached certain definite decisions regarding the temperature rise of large electrical machines. Ninety degrees centigrade was set as the limit for rotors of steam-driven alternators and all other alternating-current machines of similar high-speed construction with Class B insulation; 60 deg. cent. for Class A and 80 deg. cent. for Class B insulated rotors of salient-pole machines above 750 kva. and of which the stator cores exceed 50 cm. in length axially; 60 deg. cent. for Class A insulated and 80 deg. cent. for Class B insulated steam-turbine-driven alternators and all other alternating-current machines of similar high-speed construction having an output of 5000 kva. or more and two or more coils per slot. For such machines with one coil per slot and with windings up to 7000 volts, the Class A limit was set at 55 deg. cent. measured by detector outside coil insulation, and 55 deg. cent. measured by

detector inside coil insulation. For Class B insulation the limits under the same measurement conditions were set at 70 deg. cent. and 80 deg. cent., respectively. For salient-pole machines of 5000 kva. the same temperature limits under the same conditions as the preceding were set. The insulation classifications mentioned here are practically identical with those which have prevailed for some time in the United States. Class A represents impregnated organic materials and Class B inorganic materials with a binder.

Professor Morelli, of Turin, presented an able discussion of the subject of temperatures and suggested the following conclusions: First, that temperature rise affects the size of a machine and is an attribute of rating; second, that ambient temperature is a condition affecting service, is not an attribute of rating, and effects rating standards only indirectly in that a high-standard ambient temperature operates to reduce the standard temperature rise; third, that total temperature limits are to be determined by experience in the operation of machines and by other experience relating to the time-temperature characteristics of insulating materials, these limiting temperatures also appearing behind the scenes in rating standards; fourth, that in the formulation of standards of rating, ambient-temperature and local-temperature limits are used to arrive at standard temperature rises, and the rises are the only temperatures directly associated with the test rating.

An example of the spirit of the I.E.C. was afforded in the matter of marking battery terminals. It was found that while all the other countries used red for the positive and blue for the negative terminals, the practice in Czechoslovakia was exactly opposite. When this came up Professor List, representing Czechoslovakia, stated that his country would cheerfully reverse their practice, upon which the positive red and negative blue were unanimously recommended for adoption.

Another matter which came up was that of the dimensions of bayonet lamp caps and holders. Formerly differences existed in the several countries using this type of holder. Through the efforts of the I.E.C. these differences have been successfully eliminated. The problem of the screw cap and holder is proving more difficult as there is a difference in the depth of thread between the continental and American standards. A compromise thread is in sight, however, which will probably not necessitate the scrapping of the vast number of holders which are already in use the world over.

The Advisory Committee on Insulating Oils in the course of its discussions made considerable progress and recommended to the national committees the following recommendations:

(*a*) That the viscosity of transformer oil be expressed as kinematic viscosity, using as a unit the kinematic centi-poise.

(*b*) That during the next year the viscosity of transformer oil shall be determined at 20 deg. cent. and 40 deg. cent. to the end that at a future meeting of the Advisory Committee a decision can be reached to adopt a single temperature.

(*c*) That in order to arrive at a practical short-time acceptance test, the research test has to be established first. After all practical and recognized forms of research test have been considered, then the question of the acceptance test to be adopted could be decided. At present only the research test is to be studied and the National Committee should retain their present acceptance tests.

(*d*) That in order to obtain data to furnish the basis of discussion at the next meeting of the Commission, the following four characteristic tests on transformer oil shall be made: Swedish, Swiss, German, U. S. A.

These tests to be carried out at the following two temperatures:

(*a*) At the standard temperature as prescribed by the National rules

(*b*) At a temperature of 110 deg. cent.

The Experts' Papers during the I.E.C. convention corresponded in character to those of the familar A.S.M.E. technical sessions. One subject in particular attracted much attention in this direction, namely, the importance in each country of the demand for an overload and the main reasons for such a demand. This was discussed, at the invitation of Dr. Semenza, by the following authorities: F. Dupont, of Belgium; Prof. C. F. Hirshfeld, of Detroit; A. Huber-Ruf and Dr. Behn-Eschenburg, of Switzerland; C. Rodgers, of Great Britain; R. Liljeblad, of Sweden; and Dr. M. Kloss, of Germany. Other subjects and authors were: The Ambient Temperature as a Testing Temperature of Reference and as a Climatic Entity, by Roger T. Smith, of Great Britain; The True Meaning of Ambient Temperature, Limits of Temperature and Temperature Rise, by Prof. E. Morelli, of Italy; Is it Possible to Formulate General Laws of Equivalence Between Electrical Machines Having Ratings with Different Temperature Rises? by A. Huber-Ruf and Dr. Behn-Eschenburg, of Switzerland; and Can the Thermal Capacity of Electric Machines Be Made a Simple and Practical Element of Rating? by Dr. A. E. Kennelly.

After a general discussion of these papers Professor Feldmann, the chairman of the Rating Committee, summarized the conditions by stating that there is no general demand for the inclusion of a sustained overload in the I.E.C. rating, and if conditions do make a second rating desirable, the I.E.C. rating should be stated upon the nameplate of the machine.

VISITS TO INDUSTRIAL CENTERS

The trip which followed the New York meeting was filled with pleasant and instructive events for the delegates and the hospitality which began in New York continued through its whole course. At Philadelphia, the Richmond Street Station of the Philadelphia Electric Co., whose guests the delegates were, was visited, followed by a tour of the city and visits to the Philadelphia Country Club and the University of Pennsylvania.

Washington was reached early Saturday morning, April 24, and twenty-four hours were spent there. Breakfast at the Mayflower Hotel was followed by a sight-seeing trip. The delegates were received at the White House by President Coolidge. Luncheon was served at the Bureau of Standards, and the laboratories were inspected. In the evening the Washington Society of Engineers gave a dinner to the visitors at the Mayflower Hotel, at which Secretary Herbert Hoover, who was head of the Washington committee of arrangements, spoke. He complimented the delegates upon the fact that their deliberations had closed in a spirit of accomplishment instead of one of apology. He urged that an effort now be made to discover a substitute for that "misused, abused, and worn-out word—standardization."

At Pittsburgh, on Sunday and Monday, April 25 and 26, the joint hosts were the Duquesne Light Co., the West Penn Power Co., the Carnegie Steel Co., the Westinghouse Air Brake Co., and the Westinghouse Electric & Manufacturing Co. President Church of Carnegie Institute headed the committee. The Carnegie Steel Co. provided a roofed barge on which the visitors were carried up the Monongahela River through the great industrial district and to the McKeesport plant of the National Tube Co. After inspecting this they were carried by motor buses to the Westinghouse East Pittsburgh plant for luncheon, and later through the parks and boulevards. Tea was served at the Carnegie Art Galleries, and dinner at the Pittsburgh Golf Club.

At Chicago on Tuesday the Commonwealth Edison Co. was host. Here an early motor-coach tour of the water front and business section was made, and the party was welcomed at luncheon at the South Shore Country Club by Dr. Max Mason, president of the University of Chicago. In the afternoon the parks and boulevards were visited, dinner was served at the Edgewater Beach Hotel, and the evening was spent at the Olympic Theater.

Detroit was reached early Wednesday morning. The hosts were the Detroit Edison Co. and the Ford Motor Co. After visiting the River Rouge Ford plant, luncheon was served at the Detroit Edison Trenton Channel power plant. The visitors were taken to their train at Windsor, Ont., by automobiles.

Thursday and most of Friday were spent at Niagara, where the joint hosts were the Hydroelectric Power Commission of Ontario and the Niagara Falls Power Co. After a thorough inspection of the great hydroelectric developments and manufacturing projects around the Falls, the visitors made a trip to Toronto, Ottawa, and Montreal under the guidance of John Murphy, of the Dominion Department of Railways and Canals.

Visits to Boston and Schenectady followed the Canadian tour. In these cities the hospitality evident elsewhere was also extended, and visits to industrial, historic, and scenic points were enjoyed. New York was finally reached on Wednesday, May 5, thus completing the trip.

A.S.M.E. Holds New England Meeting in Providence

Registration of 700, Seven Excellent Technical Sessions, and Numerous Entertainments and Excursions Characterize Regional Meeting

THE Providence Meeting of The American Society of Mechanical Engineers, held from May 3 through 6, 1926, was a splendid realization of the hopes of members of the Society that the Regional Meetings, started in 1922, would eventually reach the status of the Spring Meetings, and that the members of the Society throughout the year would have several opportunities to get together in the interests of the profession.

The Providence Meeting was a great success. There were seven excellent technical sessions prepared with the coöperation of the Professional Divisions, and there was an excellent program of entertainment and excursions, and an especially fine list of events for the ladies. The registration reached 700, which exceeded that of many Spring Meetings. Throughout the four days of the meeting the weather was crisp and clear, and this added greatly to the success of the various excursions and entertainment.

The Providence Engineering Society coöperated wholeheartedly not only in the publicity for the meeting but in assisting in the conduct of the various excursion events. The A.S.M.E. Sections of New England also rendered invaluable assistance in developing interest in the program for the meeting.

Entertainment Events

The entertainment program started on Monday evening, May 3, with a reception at the Rhode Island School of Design. The guests were permitted to ramble through this splendid exhibition of American paintings and architecture, and thoroughly enjoyed the showings of old American silverware and furniture. The receiving line comprised the Local Committee, the President of the Providence Engineering Society, the wives of these gentlemen, and Thomas L. Wilkinson, Vice-President of the Society, who represented President Abbott in his absence. The reception was followed by a Bohemian supper at the Art Club.

On Tuesday the members attending the meeting sat at luncheon with the Providence Chamber of Commerce Committee of One Hundred in the ballroom of the Providence-Biltmore. Robert S. Holding, Chairman of the Committee of One Hundred, presided. Prof. R. W. Angus, Vice-President of the Society, spoke in the absence of President Abbott. The speaker was Prof. H. E. Clifford, of the School of Business Administration of Harvard University, who spoke on the Relation of the Engineer to Business.

In the evening a party of about three hundred enjoyed an automobile drive to Rehoboth, where a genuine Rhode Island clam bake was served. This was followed by an informal entertainment which completed a thoroughly enjoyable day.

On Wednesday the ladies held a May breakfast at Oaklawn, which was attended by a large number of the men. In the evening there was an informal dinner in the ballroom of the Providence-Biltmore. Henry D. Sharpe presided, and after a word of greeting from Mayor Gainer of Providence, Samuel H. Libby spoke on The Engineer's Opportunity. Sherwood F. Jeter, Vice-President of the Society, responded in his characteristically happy manner in the absence of President Abbott. Past-President John R. Freeman read a cablegram from Secretary Rice, who is at present in Germany.

Excursions

The excursions and shop visits were very well planned and conducted. On Tuesday parties visited the plants of the Brown & Sharpe Manufacturing Company, the United States Rubber Company, and the Narragansett Electric Lighting Company. On Wednesday excursions were made to the following plants: Grinnell Company, Inc., Providence Gas Company, Hope Webbing Company, American Textile Company, and Narragansett Machine Company.

Thursday was devoted to an all-day excursion to Newport, R. I., where the Naval Training Station and the Torpedo Station were visited. Over 600 people took the trip to Newport and enjoyed the interesting program which the United States Navy presented. In the morning there was a special exhibition drill at the Naval Training Station under the direction of Commander W. F. Amsden. President A. F. Thornley of the Providence Engineering Society, Past-Presidents John R. Freeman and Charles T. Main, William Elmer, member of Council, and Luther D. Burlingame, Chairman of the Providence Committee, reviewed with Commander Amsden. The party then proceeded by Government ferry to the Torpedo Station. After luncheon in Jack's House there was an interesting program. Captain E. B. Larrimer, Commanding Officer of the Torpedo Station, welcomed the guests. He was followed by James W. McConnell, who told of The Relation of the Government Departments to the Engineering Profession, and by Lt-Com. J. L. King, who described The Mechanism and Engineering Features of the Torpedo. The ladies were escorted on board a destroyer, which made the trip to the launching barge where an exhibition of torpedo launching was given. The men were permitted to inspect the machine shops where the interesting and delicate mechanisms for torpedo operation were shown. After returning to the Training Station, the party then made a short tour about Newport and returned to Providence.

Ladies' Entertainment

Many comments were made regarding the splendid manner in which the ladies' program was planned and conducted. Mrs. Henry D. Sharpe entertained at luncheon at her home at Nayatt on Monday, and in the afternoon Mrs. Zechariah Chafee gave an informal tea at "Laneway," Taunton, Mass., both affairs being thoroughly enjoyed by the visiting ladies.

On Tuesday morning the ladies enjoyed a sight-seeing trip to the interesting and historic sights of Providence. Mrs. John R. Freeman acted as hostess at luncheon at the Providence Plantation Club, after which there were excursions to the plants of the Gorham Company and of Ostby & Barton.

Wednesday morning a delightful sight-seeing trip through the Rhode Island country to the new Scituate Dam and Reservoir was taken, and at noon a May breakfast was served at the Ancient Meeting House, Oaklawn. In the afternoon an exhibition golf match was arranged at the Rhode Island Country Club, with an invitation tea following.

The splendid success of the Providence Meeting was due to the energetic efforts of eleven committees acting under the following chairmen, and of representatives of six of the Society's other New England Sections: Luther D. Burlingame, Chairman, and Norman L. Sammis, Secretary, Main Committee; Frederick C. Freeman, Chairman Finance Committee; James A. Hall, Chairman Technical Events Committee; Eugene W. O'Brien, Chairman Printing and Signs Committee; Warren B. Lewis, Chairman Hotel Committee; Charles G. Richardson, Chairman Entertainment Committee; Samuel D. Fitzsimmons, Chairman Excursions Committee; William A. Kennedy, Chairman Information and Registration Committee; William H. Kenerson, Chairman, Publicity Committee; John R. Freeman, Chairman Reception Committee; Mrs. Henry D. Sharpe, Chairman Ladies' Committee; and the following representatives of New England Sections: John R. Carlson, Boston; H. E. Wells, Bridgeport; Herman S. Hall, New Britain; H. R. Westcott, New Haven; G. E. Pellissier, Western Mass.; M. C. Nelson, Worcester.

Council Meeting

In the absence of President Abbott, Vice-President William T. Magruder presided over a two-day session of the Council of the Society. Monday, May 3, was devoted entirely to the preparation of

the budget for the fiscal year beginning October 1, 1926. On Tuesday routine matters were taken up. Among the important actions were the granting of permission for a Local Section to a group of members in Rockford, Ill., and Beloit, Wis. The Section will be known as the Rock River Valley Section. White Sulphur Springs, W. Va., was selected for the meeting of the 1927 Spring Meeting. Final action was taken amending the By-Laws and Rules which now provide for a five-year term for all members of the Executive Committees of the various Professional Divisions.

Session on Apprenticeship Training

AT WHAT appeared to be an alumni meeting of Brown & Sharpe trained apprentices at the Session on Industrial Education held on Monday afternoon, May 3, the need for apprentices and the value of apprenticeship training were stressed by nearly all speakers. C. R. Burt, Vice-President and General Manager, Pratt & Whitney Co., Hartford, Conn., acted as chairman.

The formal program of the session consisted of three papers, Has the Need for Apprenticeship Passed? by W. A. Viall, Vice-President of the Brown & Sharpe Mfg. Co.; Essentials of Safety Education, by George E. Sanford, Safety Engineer, General Electric Co., Schenectady, N. Y.; and Training for Foremanship, by Frank Cushman, Chief, Industrial Education Service, Federal Board for Vocational Training, Washington, D. C.

Mr. Viall presented a negative view of his subject, supported by details of the experience and methods successfully employed by the Brown & Sharpe Company, over a period of years. While he felt that school training, when successful, prepared a man to obtain the advantages of shop training in a much shorter time than was apt to be the case with an untrained mind, he firmly believed that it could in no way take the place of actual shop conditions. He outlined the methods of the Brown & Sharpe Co., their ideals and their relations with apprentices, and gave statistics to show what became of the trained men.

In a written discussion of Mr. Viall's paper, J. C. Spence, of the Norton Grinding Co., Worcester, Mass., pointed out that the shortage of skilled labor due to immigration policy necessitated the training of men for the skilled trades, and that the shortage of unskilled labor resulted in the necessity for machines to do the work of these men and hence a greater need for apprenticeship.

An improvement in the apprenticeship methods of the Brown & Sharpe Co., was noted by Ralph E. Flanders, Manager, Jones & Lamson Machine Co., Springfield, Vermont (Mem. A.S.M.E.), who had served an apprenticeship with the well-known Providence concern. Henry Buker, Vice-President of the Brown & Sharpe Co. and a graduate of the apprenticeship course (Mem. A.S.M.E.), testified to its value to him and to his belief in the methods used.

His own difficulty in getting into the line of work for which he was best fitted led Charles L. Newcomb, Manager, Deane Works, Worthington Pump & Machy. Co., Holyoke, Mass. (Mem. A.S.M.E.), to a belief in the apprenticeship method. He told of his early drifting from one thing to another until the machine shop of the Deane Works gripped his interest strongly enough to hold him for forty-five years. He was, he said, an outside beneficiary of the Brown & Sharpe Co., inasmuch as he had applied the methods used by Mr. Richmond Viall in his own works at Holyoke.

Dwight K. Bartlett,[1] W. P. Hunt,[2] L. S. Harding,[3] and Professor Kenerson[4] also contributed to the discussion.

The paper on Essentials of Safety Education had not been prepared in advance, and Mr. Sanford presented it extemporaneously. He divided shops into three classes: those who depended entirely on insurance companies for safety measures, those who maintained a safety committee, and those who placed matters relating to safety in the hands of a large committee which included workmen. He outlined the methods of safety education adopted by the General Electric Co., and quoted many interesting statistics showing the effects on the number and severity of accidents by methods which had been put into practice. Safety education was good economy, he said, a saving of $35,000 having been made in one instance at a cost of $2500.

Col. John Price Jackson, Assistant to Vice-President, New York Edison Co. (Mem. A.S.M.E.), quoted some accident statistics. In answer to a question by Mr. Bartlett on the difference in the hazards in different departments, Mr. Sanford said that there seemed to be no reason from his experience to expect that an unusually hazardous department could not be educated to eliminate accidents, and that in competition with less hazardous departments those with the greater dangers were frequently ahead.

Mr. Cushman's paper was an analysis of educational systems applicable to this form of training. It is to be published later in MECHANICAL ENGINEERING. In discussion of the paper, Mr. Viall said that all apprentices were prospective foremen, and that in the Brown & Sharpe Co., foremen were working foremen who were growing up to be superintendents.

John Bath, President and Treasurer, John Bath & Co., Inc., Worcester, Mass. (Mem. A.S.M.E.), and Fred Ayer, Engineering College, University of Akron (Ohio), also discussed the paper.

Session on Small-Parts Manufacture

THE Machine Shop Practice Division conducted a session devoted to Small-Parts Manufacture on Tuesday morning, May 4, in the Providence-Biltmore Hotel. James H. Connolly, member of the Executive Committee of the Machine Shop Practice Division, presided.

H. G. Wiberg[5] spoke on the Safety Code for Mechanical Power-Transmission Apparatus. He described the methods by which this Code was formulated under the procedure of the American Engineering Standards Committee and emphasized its importance to manufacturers as it contains in a convenient and accessible form authoritative sources of information for the safeguarding of power-transmission equipment.

Paul E. Holden,[6] director of field work of the Investigation in relation to safety and production to be conducted by the American Engineering Council, outlined briefly the work that the investigation will cover. He bespoke the coöperation of industry in this study.

The first paper of the morning was that by A. C. Danekind on The Development of Tap-Drill Sizes. This appeared in the May issue of MECHANICAL ENGINEERING.

In the discussion J. Howard Ayer[7] emphasized the great importance of maintaining tapping and drilling tools and fixtures in the best possible condition in order to give good tap work, to reduce tap breakage, and to increase production.

R. E. Flanders[8] spoke of the importance of the practical work which Mr. Danekind had completed in working out the values of drill sizes for various kinds of material with a 75 per cent engagement between the bolt and the nut.

The second paper was one by Joseph Kaye Wood[1] on The Specification and Control of Mechanical Springs. Mr. Wood's paper and the discussion will appear in abstract in the July issue of MECHANICAL ENGINEERING.

The influence of Design on Production was the subject of a paper by Earle Buckingham, which appeared in the May issue of MECHANICAL ENGINEERING. In the discussion John Younger[9] pointed out that the economic value of tolerances was not as thoroughly understood as it might be. It was a mistaken idea that fine limits were necessary for quality. He also emphasized the importance of Professor Buckingham's statement that sizes and shapes of machine surfaces should be standardized and the number of production tools should be kept as low as possible. In closing he directed special attention to the great importance of paying close attention to the cost of design changes.

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[1] Builders' Iron Foundry, Providence, R. I.

[2] President, Moline Tool Co., Moline, Ill. Mem. A.S.M.E.

[3] Blake & Knowles Works, Worthington Pump & Machinery Co., Cambridge, Mass.

[4] Professor of Mechanical Engineering, Brown University, Providence, R. I. Mem. A.S.M.E.

[5] Chief Engineer and Underwriter, Lumber Mutual Casualty Co., New York.

[6] Director, Field Work Safety and Production, American Engineering Council, Washington, D. C.

[7] Tool Supervisor, General Electric Co., Pittsfield, Mass.

[8] Manager, Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.

[9] Professor of Industrial Engineering, Ohio State University. Mem. A.S.M.E.

Sanford E. Thompson,[10] speaking from the viewpoint of the management engineer, expressed complete agreement with the substance of Professor Buckingham's paper. He pointed out that the functions of the mechanical and management engineers were closely allied and supplemental to each other. Simplicity in design and standardization of sizes, shapes, and parts to simplify and expedite matters of production control and financing were aims of the management engineer in which the coöperation of mechanical engineers, designers, and sales managers was needed. All of these factors were important if workmen were to be supplied with needed information and if the selection of manufacturing processes and refinements in production methods were to be profitably secured.

T. C. Bryant[11] gave an example of a plant where a large number of sizes of tap holes in a machine had been replaced by five sizes, with a consequent decrease in production cost and decrease in the amount of money invested in small tools and other equipment.

Theodore H. Nye[12] called attention to the fact that simplification could be successfully applied in a factory engaged in the production of a variety of products rather than a large quantity of one product. He stated that in the manufacture of equipment for rolling steel billets, merchant bars, skelp, etc., the number of roll-housing units had been reduced from 50 to 25, pinion housings from 30 to 15, roller tables from 25 to 6, and sizes and types of shears 50 per cent. Further, in an analysis of the raw materials used, 15 per cent of the diameters and lengths of rough bolts had been eliminated and the number of sizes of shafting used in quantity in many places had been reduced, writing off 60 per cent from the stock list. In addition to the decreased shop cost from such simplified methods, the cost of drawings had also been reduced.

The final paper of the morning was one presented by Luther D. Burlingame, entitled A Basis for Determining the Proportions of Standard T-Slots and Bolts.

Industrial-Power Session

PROF. WILLIAM H. KENERSON, Past Vice-President of the Society, presided over the session on Industrial Power held under the auspices of the Power Division on Tuesday morning, May 4, in the Providence-Biltmore Hotel. The two papers presented elicited a large amount of discussion, which will be reported more completely in a later issue of MECHANICAL ENGINEERING. The first paper, by S. D. Fitzsimmons, on Industrial-Boiler Efficiencies, appeared in the May issue of MECHANICAL ENGINEERING. The second paper, by Marcus K. Bryan, on Selecting a Power and Heat Supply for Industrial Plants, will be found elsewhere in this issue.

Wood-Industries Session

THE session devoted to wood industries, under the auspices of the Wood Industries Division, was held on Tuesday morning, May 4, and was well attended. Wm. Braid White, chairman of the Wood Industries Division, acted as chairman in charge of the session.

Mr. White spoke of the work which had been undertaken by the Division during the past year and of plans for the Annual Meeting of the Society next December, at which time the Division is to have a program of papers devoted to wood finishes. He spoke also of the possibility of undertaking a research in spark arresters.

Before the presentation of the papers which constituted the program of the session, L. P. Alford[13] addressed the meeting on the coöperation between the American Engineering Council and the National Bureau of Casualty Underwriters in a study of safety in American Industry. The study is to determine the relation between safety in industry and good management, a fact which is recognized, but which, if proved statistically, will give impetus to the general safety movement in this country.

A Safety Code for Woodworking Plants was the subject of a paper by E. Ross Farra.[14] He gave a brief history of the code drawn up under the leadership of the American Engineering Standards Committee, and a list of its sponsors and the coöperating organizations. He pointed out the fact that the adoption of the code by a majority of states would assist manufacturers in standardizing their guarding systems, and urged that members of the Society exert their influence toward its adoption. Engineering departments of industries were also asked to see that new constructions and new installations conformed to the code. The code, known as the Woodworking Code, was primarily a code for point-of-operation guarding, he said, there being other codes on mechanical power-transmission apparatus, exhaust systems, lighting, electrical, etc., dealing with the general hazards of the woodworking industry. He reported that in the woodworking industry point-of-operation accidents represented 47 per cent of the total. The high speed of operation was responsible for the high percentage of such accidents, he said.

The first section of the code deals with plant layout; the second takes up machine drive, feed, speed, and control, and the third considers guards for various types of saws, and also jointers; the fourth, veneer machinery; the fifth, cooperage machines; the sixth, rules for inspection and maintenance of machinery; the seventh gives explanatory matter regarding location of heavy-duty machinery, foundations, individual motor drive, lighting, selection of machines for work being done, speed, cracked tools, etc.

Charles D. Fair,[15] in discussing the paper, said that due to disagreements between safety inspectors he had found it difficult to provide woodworking machinery with generally acceptable guards, and for this reason the problem of guarding was left to the user of the machine.

William F. Sticht[16] spoke of difficulties with exhauster systems, and Mr. Farra referred him to a separate code covering these.

Col. John Price Jackson[17] urged every member to work for the adoption without material modifications of such codes as the one under discussion, so that it would be possible for manufacturers to standardize practice in guards.

The second paper of the program was by C. L. Babcock,[18] on Refinements in Woodworking-Machinery Design. The paper appeared in the May, 1926, issue of MECHANICAL ENGINEERING, and in the absence of the author was read by his associate, G. L. Parker,[18] who illustrated the presentation with lantern slides. The paper dealt with modern improvements as exemplified by fast-feed planers and molders; motor-driven planers, shapers, and tenoners; automatic shaping lathes; and multiple and gang borers.

W. H. Rohr[19] contributed a written discussion in which he called attention to the milled-to-pattern cutter for matchers, molders, shapers, and tenoners, which is made of high-speed steel in the form of straight knives and circular, multiple-wing cutters centrally bored to fit machine arbors. He classified refinements incorporated in woodworking machines during recent years as having the following objectives: (1) To effect more continuous operation; (2) to increase output; (3) to reduce the cost and attention required for maintenance work; (4) to simplify and speed up adjustments and to attain greater precision in this work, and (5) to provide maximum safety. The features which had been provided by manufacturers to these ends he summarized as follows: (1) Fittings on slow-speed bearings for pressure-gun lubrication; (2) magazine or hopper feed mechanisms; (3) built-in magnetic switches operated by push buttons; (4) switches to prevent reversing, etc.; (5) built-in dust and shavings hoods; (6) built-in enclosures for gears and transmission apparatus; (7) graduated dials on or in connection with handwheels for precision adjustment; (8) heavier castings, spindles, and bearings to withstand the strains of higher speeds and increased production.

Mr. Cassebier, of the Steinway Piano Company, told of the increased production which he had obtained from existing building

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[11] Manager, Gage Department, Greenfield Tap & Die Corp. Assoc-Mem. A.S.M.E.

[12] Engineer, Morgan Construction Co., Worcester, Mass. Mem. A.S.M.E.

[13] Editor, *Manufacturing Industries*, New York, N. Y. Mem. A.S.M.E.

[14] U. S. Gypsum Co., New Brighton, S. I., N. Y.

[15] Chief Engineer, Baxter D. Whitney & Son, Inc., Winchendon, Mass. Mem. A.S.M.E.

[16] M.E., American Lead Pencil Co., Hoboken, N. J. Assoc-Mem. A.S.M.E.

[17] Assistant to Vice-President, New York Edison Co., New York. Mem. A.S.M.E.

[18] Machinery Methods, Inc., New York.

[19] Field Editor of *The Woodworker*, 701 Wilson Bldg., Indianapolis, Ind.

space by the use of improved machinery, and T. P. Perry spoke of the excessive amount of time required for set-ups. The increased attention given by designers to the provisions for safety was acknowledged by H. G. Werbing of the Lumber Mutual Casualty Co.

Raymond W. Burns[20] presented the third paper, the subject of which was Design and Application of Clamp Carriers for Wood Gluing. The presentation was illustrated by lantern slides. The paper set forth the advantages of clamp carriers in edge gluing and their increasing use for special work such as gluing thick stock, gluing and squaring frames, end clamping, and in accommodating long stock such as show cases and church furniture. It was published in MECHANICAL ENGINEERING for May, 1926, p. 427.

In answer to a question by G. L. Parker about the pressure exerted by clamps when set up by hand, the author said that with two-inch stock the average total pressure per clamp was between 2300 and 2400 lb.

Written discussions were submitted by J. R. Watkins and by H. C. Rice.[21]

The last paper, by S. M. Silverstein,[22] on The Technology of Wood Finishes and Their Application, discussed the chemistry and physics of present-day finishing materials and methods of application, and the need for fundamental research work in developing new materials and improving methods of application. The paper was published in MECHANICAL ENGINEERING for May, 1926, p. 423.

Walter L. Edgar[23] and F. L. Browne[24] submitted written discussions.

Mr. Watkins wrote that the airplane exemplified the possibilities of built-up wood, and that propellers represented the refined requirements of practice in glued wood from the standpoint of manufacture. He discussed the relative strengths of bolted and glued built-up beams and columns. There was no objection, he wrote, to excessive time under pressure, but there was serious objection to relieving the pressure too soon.

Mr. Rice mentioned the increased use of clamps and clamp carriers due to the greater use of small lengths and widths of lumber. He agreed with the author that strains in kiln-dried lumber might be relieved by ripping, but said that no amount of ripping would cure the defects of imperfectly dried lumber. He emphasized the importance of keeping machines in such shape that straight-line stock would be delivered to the man at the glue clamp.

Mr. Edgar endorsed what Mr. Silverstein had said in his paper and spoke of the difficulties of marketing a new lacquer. He agreed that the wood industry was in the period of developing an ideal finish. A material with the qualities of lacquer plus good filling was in process of development at the present time. He wrote extensively of the properties and quality of lacquer, and ended by saying that there was a growing tendency among salesmen to sell the finish most suitable for the consumer.

Mr. Browne spoke of the difficulty of introducing scientific methods into the wood-finishing industry, which he attributed to the neglect of this problem on the part of chemist and physicist. He agreed with Mr. Silverstein that real progress in "wood-finishing engineering" would depend on a thoroughgoing revision of present methods of staining and filling preparatory to the application of the finish. He felt that some day means would be found for staining without "grain raising." He thought it profitable to devote research to finding methods of making cheap, non-aqueous wood stains which would not bleed in lacquer solvents.

Mr. Cassebier and Mr. Perry also contributed to the discussion.

Session on Pressed Metal

THE Machine-Shop Practice Session devoted to pressed metal was held in the morning of May 5, under the auspices of the Machine-Shop Practice Division of the A.S.M.E. and the National Machine Tool Builders' Association. Erik Oberg, treasurer of the Society, presided. The first paper, read by E. C. Mayo,[25] entitled New England Conditions Affecting the Machine-Tool Industries, follows:

NEW ENGLAND CONDITIONS AFFECTING THE MACHINE-TOOL INDUSTRIES

PRIOR to the Napoleonic Wars New England depended upon its commerce for a livelihood. During these wars its vessels were erased from the seas. As a result the New Englanders, encouraged by the existence of an abundance of water power afforded by its rivers, engaged themselves in manufacturing. This was the beginning of its industrial manufacturing supremacy.

Naturally they had no domestic competition and as the product of their labors was water-borne to its destination, geographical location was of little consequence.

In spite of the fact that this country has spread from coast to coast and from Canada to Mexico, and in spite of the fact that she has no raw materials within her boundaries, New England has continued to hold her own until the present generation. The foundation of this supremacy was laid by the hand of necessity in what was then a suitable geographical location.

This position was maintained by a monopoly of skilled mechanics. The natural product of the skilled mechanic is invention. Invention is covered by patents. Hence New England attained the heights of success by a monopoly of skilled mechanics and entrenched herself with patents.

Strategically this position was economically unsound unless strengthened by other factors.

The New England mechanics have migrated to other parts of the country and one will find them as mechanics, foremen, superintendents and chief engineers, as well as managers of some of the leading plants in the central and middle-western states. When these men located in other sections of the country they sent back home for help. New England's stock in trade—her skilled mechanic—was gradually diffused over other sections of the country.

This resulted in the establishment of manufacturing plants that immediately went into keen competition with those of the mother section and as a result New England products could be obtained elsewhere than in New England, sometimes at a lower price and sometimes under more favorable conditions.

As New England shared her skilled mechanics with other sections of the country, she lost her patent supremacy. The two went hand in hand.

In 1850, out of a total of 875 patents granted, 385, or 40 per cent were granted to New Englanders. In 1880, out of a total of 12,655 patents granted, 2442, or 19¾ per cent, were granted to New Englanders. In 1924, out of a total of 40,530 patents granted, 4303, or 10.6 per cent, were granted to New Englanders. This is a very significant picture and proves the theory that New England has not only lost her monopoly of skilled mechanics, but also her patent supremacy.

The failure to balance this loss of skilled mechanics and patents by introducing the most up-to-date machinery is one of the controlling factors in the present situation.

The failure to recognize this situation has not been due to a lack of keenness on the part of the New Englander, but is the result of an inherent fear of invested capital and a state of complacency or self-satisfaction which is the natural outgrowth of the monopolies in skilled labor and patents which they have enjoyed for generations.

It has been the author's privilege to know, personally, some of the outstanding business men and manufacturers in this section.

Here is the philosophy of one of them. He would rather operate a machine that has been written down to $2 on his books than to purchase the most up-to-date unit at any price. The theory being that the $2 machine, because of the low interest and depreciation charges, can in good times (prices being reasonably high) compete with the more expensive machine, and in hard times both will be idle and the high-priced machine will eat itself up.

Buying machine tools because they are cheap to purchase, not cheap to operate, is a dangerous philosophy. This is an example

(*Continued on page 644*)

[20] M.E., J. L. Taylor Mfg. Co., Poughkeepsie, N. Y. Assoc-Mem. A.S.M.E.

[21] Factory Manager, C. Kurtzmann & Co., Buffalo, N. Y. Mem. A.S.M.E.

[22] Director of Industrial Research Division, Bigelow, Kent, Willard & Co. Inc., Boston, Mass.

[23] Flood & Conklin Co., Newark, N. J.

[24] Chemist, Forest Products Laboratory, Madison, Wis.

[25] President and General Manager, Gorham Manufacturing Co., Providence, R. I. Mem. A.S.M.E.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

European Hydraulic Laboratories and Their Work

DIE WASSERBAULABORATORIEN EUROPAS (The Hydraulic-Construction Laboratories of Europe). V.D.I. Verlag, Berlin, 1926. Quarto, 431 pp., illus., $12.50.

ONE of the by-products, and a notable one, of the 1924 London Power Conference, is the quarto volume having the above title. Conrad Matschoss, the V.D.I.'s tireless special secretary, charged with the duty of supervising its biographical, historical, and general literary work, tells us in his Introductory Remarks that the book owes its origin to a well-known American engineer, no other than John R. Freeman, of Providence, R. I.; and from other sources it may be asserted that making a tour of European hydraulic laboratories after the Power Conference, Mr. Freeman was so impressed by the work he saw going on in them, that he immediately set about arguing for its publication, and at the same time gave the plans for such publication a most practical impetus.

No combination other than the V.D.I. as represented by Matschoss, and Freeman, could better have undertaken the task, whose outcome is before us.

Fourteen managers of as many of the leading hydraulic laboratories of Europe, besides several other distinguished engineers, have contributed to its pages. Let us name them:

Rehbock of Karlsruhe	Smrcek of Brünn
Engels of Dresden	Schulze of Danzig
Krey and Winkel of Berlin	Forchheimer and Schocklitz of Graz
Thoma of Munich	Grantz of Charlottenburg
Krüger of Wilhelmshaven	Carstanjen of Darmstadt
Möller of Brunswick	Fellenius of Stockholm
Schaffernack of Vienna	Timonoff of St. Petersburg

I have named them in the order, roughly, of the amount of work apparently accomplished by their respective laboratories. All these contributed, giving the history of the institutions over which they preside; an account of the work that has been done there; and last, but not least, a bibliography of books and articles in technical journals that have described such work. In the language of the "barker" at the entrance to "America's Greatest Wonder Exhibiting Show" at "our County Fair," this "last alone is worth the whole price of admission." As surplusage we have articles of great philosophical and instructional value from Messrs. G. de Thierry, Matschoss, and Freeman.

A loving tribute to the pioneer work in hydraulic-laboratory investigations of Koch of Berlin, deceased, is given on page 421. The last paragraph on page 45 may well be heeded by all managers of hydraulic laboratories, present and to come. Its attainment may be expected when hydraulic laboratories will have been endowed to the extent of being able to work continuously, as work its exemplars in astronomy; thus meriting the name of hydraulic observatories.

An unanswerable argument in behalf of government hydraulic laboratories may be found on page 192; and throughout the whole book, by nearly every one of its score of contributing authors, the point is put forward, and is proved, that the projectors of novel or important hydraulic public works cannot afford to enter upon their task without having at hand and available the results of tests of models of such constructions. Naturally, the art or science of computing and constructing full-sized engineering works, after the lessons taught by experiments on models, is extensively dealt with in this connection.

But it would lead too far to attempt to quote a selection only of all the good thoughts one could cull from this volume; the blossoming forth of practical wisdom never before gathered together and systematized; lying latent, as it were, in the outpourings mainly of German engineering literature; and now come to fruition.

CLEMENS HERSCHEL.[1]

The American Year Book

THE AMERICAN YEAR BOOK. A Record of Events and Progress for the Year 1925. Edited by Albert Bushnell Hart and William M. Schuyler, with the Coöperation of a Supervisory Board Representing National Learned Societies. The Macmillan Company, New York, 1926. Cloth, 5 1/8 × 7 3/4 in., 1158 pp., $7.50.

THE reappearance of this authoritative compendium of annual progress in the various constituent elements of our civilization will be hailed with satisfaction by all who are interested in having at hand some account of the passing events as they weave themselves into the complex mesh of our material and social life.

Of special interest to engineers are the sections on science, in which are given some account of the more important advances in the various fields of fundamental science—advances which so often require the aid or leadership of the engineer in order to carry them on to the point of service to humanity.

Obviously no condensation or abstract of this material is possible in the few lines of reference here permitted. Some three hundred topics are treated under five general subdivisions which cover the field of fundamental and applied science, aside from what is commonly grouped in the broad major fields of engineering. These indeed have their chapter, but notice of this is not included in the brief sketch here given.

From among this wealth of material only a few indications can be selected, and reference must be made to the book itself for any adequate idea of the character and extent of the ground covered.

Thus in mathematics, new fields have been studied and definite progress has been made in the preparation and printing of monographs in special fields of work, and in mode of treatment adapted to reading by those who are not specialists in the subject.

In astronomy, progress has been made in the study and interpretation of the Magellanic clouds, of the special nebulae, and of the clusters and the general evolution of the stars—to mention only these among the many still unsolved mysteries which this science presents.

In geology, important studies have been carried on regarding earthquakes and regarding the distribution and extent of certain fundamentally important mineral resources; in mineralogy, regarding crystal structure; in meteorology, regarding solar radiation; in cartography, progress has been made in the preparation and printing of important series of maps showing topography and the distribution of important natural resources and products.

In chemistry, new elements have been discovered and important advances have been made in the chemical synthesis of many substances important in industry, in agriculture and in medicine.

[1] Hydraulic Engineer, New York, N. Y.

In physiological chemistry, important studies have been made regarding vitamins, those mysterious substances so vitally necessary to life and health.

In physics, experimental evidence has accumulated both for and against the theory of relativity; in atomic theory, a vast amount of time and energy are being devoted to the study of atomic structure and the electron theory of matter and many important results have been reached.

In biological science, notable advances have been made in the understanding of the nature and origin of mutations and of what are termed species. This has involved much work with the chromosomes and with the so-called genes, those seemingly ultimate determinants of life, heredity, and organic evolution. Important studies have also been made in other fields of biological science such as vertebrate and invertebrate zoölogy, entomology, botany, and palaeontology.

In the medical sciences likewise, notable advances have been made, especially in the study of the endocrine glands and the hormones which they secrete; in pharmacology, in the standardization of certain new materials such as insulin and in the development of new substances of promise; in bacteriology, in further and important studies in tuberculosis and cancer; in matters relating to surgery and in various subjects of importance in public health.

But these are only a few samples. The interested reader must consult the volume itself where he will find more complete accounts of these and of other cognate topics, as well as of matters dealing with all of the more important phases of human activity as reflected in the elements of our modern life and social organization.

W. F. DURAND.[1]

Metallurgy and Its Influence on Modern Progress

METALLURGY AND ITS INFLUENCE ON MODERN PROGRESS. By Sir Robert A. Hadfield, Bart. Chapman & Hall, Ltd., London, 1925. Cloth, 6 × 10 in., 388 pp., 25s.

IN THIS volume, which is his latest work, Sir Robert Hadfield presents the subject in such a manner that even the general public will find it intensely interesting. To the metallurgist the book is a most valuable addition to the existing literature.

The author naturally enlarges on the influence of alloy steels, the subject to which he has devoted so much time and research. He expresses the idea that we are passing out of the age of iron and simple steel, and that we are advancing into an era which may be justly termed "an age of alloy steels," for without the use of such steels it is certain that modern civilization could not be carried on. The chapters on the properties and uses of manganese and silicon steels, heat treatment, microstructure of steels, the application of special steels, including rustless iron, give excellent descriptions of these products and the reasons why they have influenced modern progress.

While it was of course necessary for Sir Robert to mention his own work on these important subjects and the achievements he has accomplished, he devotes a very large amount of space to the description of the work of others and the early history of metallurgical progress, paying a marked tribute to the many eminent scientists and workers who have been responsible for this development. Chapter I, The Birth of Science, Chapter II, The Rise of Steam, and Chapter III, The Twentieth Century, are most interesting, and any one reading them will be well repaid for the time spent.

Sir Robert also calls attention to the value of and the part played by the scientific societies, dwelling at length, of course, on the British institutions. At the same time he pays a great compliment to the United Engineering Society of America, representative of the four senior national engineering societies, and especially mentions the Engineering Foundation, one of the three departments of the United Engineering Society. He even goes so far as to say that "the engineering future of America is in the hands of the Engineering Foundation Board," which foundation is described in its charter as "For the Furtherance of Research in Science and Engineering and for the Advancement in any other manner of the Profession of Engineering and the Good of Mankind."

[1] Past-President A.S.M.E.

The rise of education and research, and their interdependence, is clearly described in Chapter XII, and in Chapter XIII the author makes some pertinent remarks on educational methods and facilities.

In concluding this work, Sir Robert speaks of the future of science and urges workers in science not to be discouraged, but to remember the old saying that "he who ceases to aim at better things will cease to do good things."

ARTHUR L. WALKER.[1]

Books Received in the Library

AIRCRAFT INSTRUMENTS. By Herbert N. Eaton and others. Ronald Press Co., New York, 1926. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 269 pp., illus., diagrams, tables. $5.

Describes the instruments in general use in America and Europe for determining altitude, climb, air and ground speed, direction, position, engine speed, pressure, temperature, etc. The principles upon which each instrument is based are explained and the errors to which it is subject are discussed.

BALLOON AND AIRSHIP GASES. By Charles De Forest Chandler and Walter S. Diehl. Ronald Press Co., New York, 1926. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 226 pp., illus., diagrams, tables. $4.

The first part of the book gives information on the production of hydrogen and helium, their compression, storage and transportation. The second part, on the physics of gases, sets forth the physical formulas needed for aeronautical computations.

BRIDGE AT WINDSOR, VT., AND ITS ECONOMIC IMPLICATIONS. By Richard T. Dana. Codex Book Co., New York, 1926. Fabrikoid, 5 × 6 in., 75 pp., illus. $1.50.

Mr. Dana has written an interesting brief description of one of the oldest public-utility enterprises financed by private capital which is now in operation. The bridge across the Connecticut river at Windsor, Vermont, was first undertaken in 1796. The present structure, of the Town lattice-truss type, was built in 1866. The history of the enterprise, the early returns to the owners, and the construction and present condition of the bridge are set forth.

COAL CATALOG combined with COAL FIELD DIRECTORY, 1926. Keystone Consolidated Publishing Co., Pittsburgh, Pa., 1926. Fabrikoid, 9 × 11 in., 1298 pp., illus., maps. $15.

The 1926 edition shows no marked change from that for 1925, but numerous refinements have been added, which make the information more precise and complete. A thumb index is adopted which makes the book more convenient. Additional mine-location maps are given, and many new analyses of coals. The book aims to bring together all the information on American coals which is of interest to large consumers. It describes the various coals available and their properties, and indicates their uses. The coal fields of each state are described and mapped, analyses of the various seams are given and the companies mining them are listed. Detailed information is given for each mine, including its officers, equipment, capacity, etc. Such technical subjects as the fusibility of ash, strip mining, exporting, preparation, transportation, storage and coke are treated in concise, practical articles.

DESIGN OF GRAVITY-CIRCULATION WATER HEATING SYSTEMS. By F. E. Giesecke. Published by the Author, Austin, Texas, and Heating & Ventilating Magazine Co., N. Y., 1926. Cloth, 6 × 9 in., 75 pp., diagrams, tables. $3.

This is a revised, enlarged edition of a series of articles published in the *Heating and Ventilating Magazine* during 1924. It presents a method for designing these systems, based on the principle that the frictional resistance must be equal to the force maintaining flow. The book consists of a series of graded examples which explain a simple, accurate method of designing systems in which the heat will be delivered to the several radiators according to a predetermined plan. It will enable the reader, the author claims, to make satisfactory designs for any similar systems encountered in his practice.

[1] Professor of Metallurgy, Columbia University, New York, N. Y.

Providence Meeting

(Continued from page 641)

of the fear of invested capital and that it is not an isolated philosophy is borne out by the following:

New England is the greatest dumping ground for second-hand machinery in the country. The author is told that 90 per cent of the machine-tool business done in the past five years by three of the leading machinery houses in New England was on second-hand machine tools. If this is true, and his authority is in a position to know, it is a startling situation and goes a long way toward explaining some of the present conditions.

This to the author's mind is also an example of where the factor of self-satisfaction plays its part. Why should we feel we can take the discarded machine tools of our neighbors and compete against them in the open market? These tools they could not afford to operate, but we chuckle at the low prices we pay for them and manfully try to operate our establishments at a profit.

Some of our neighbors in the Middle West will throw out a machine tool that is six months old if a new one is designed that makes its operation a liability.

If we are to maintain our present position, we must follow a similar policy. Certainly to a modified extent. The day of pointing with pride to operating heirlooms in a manufacturing plant has gone forever.

The recently published work of Professors Austin and Lloyd on The Secret of High Wages, attests the truth of the foregoing statements.

With modern machine tools and its inherent mechanical ability, in spite of its geographical location, New England can compete with the world.

The present policy, pursued for a period of another ten years, will certainly cripple New England's prestige beyond a point at which it can be regained without vast expenditures of money, if at all.

Every executive should make a careful analysis of his machine-tool equipment, and have the vision and courage to scrap the machinery that cannot be profitably operated in competition.

In discussing Mr. Mayo's paper, E. F. Du Brul[26] spoke of the desirability of conducting a manufacturing enterprise with mechanical and engineering vision.

W. A. Viall[27] expressed little sympathy with those who talked so much about the trouble in New England; there was as much trouble in other parts of the country. In addition to the financial trouble there was a tendency toward complacency. The measure of success, he said, ought not merely to be the financial dividend. What was being brought forth in men, what in product, what in conditions? What did the industry contribute to the welfare not only of New England but of the United States?

D. R. Bartlett[28] also testified to the belief that New England was far from moribund industrially.

Col. T. C. Dickson, Commanding Officer, Watertown Arsenal, Watertown, Mass., spoke on The Making of Guns by Cold-Working Process. Lantern slides were used for illustrating the address and no formal paper had been prepared previous to the meeting. An opportunity to ask questions was granted, and many members and guests availed themselves of it.

F. W. Krebs[29] read his paper on The Cold Drawing of Bar Steel which was published in the May, 1926, issue of Mechanical Engineering, p. 448. The paper presented the various steps involved in converting hot-rolled steel into cold-drawn bars. A general description of the equipment was given, and factors affecting the machining quality of steel were discussed. The effects of cold drawing upon the physical properties were presented, with a tabulation showing results that had been obtained with various grades of steel. The practice described was that followed by a mill specializing in alloy steels used largely for automotive construction.

[26] General Manager, National Machine Tool Builders' Association, Cincinnati, Ohio. Assoc. A.S.M.E.

[27] Vice-President, Brown & Sharpe Mfg. Co., Providence, R. I. Assoc. A.S.M.E.

[28] Builders' Iron Foundry, Providence, R. I.

[29] United Alloy Steel Corporation, Canton, Ohio.

Central-Station-Power Session

UNDER the auspices of the Power Division a session on central-station power was held on Wednesday morning, May 5, in the Providence-Biltmore Hotel. Nicholas Stahl, of Providence, presided over the presentation of the three following papers: Comparative Performance of Air Preheaters, by Nevin E. Funk; Boiler and Stoker Performance at the Hell Gate Power Station of the United Electric Light & Power Company, by H. W. Leitch; and New Boiler Equipment of the Interborough Rapid Transit Co.'s Fifty-ninth Street Power Station, by Messrs. Reynolds, Lane, and Taggart. This last paper appeared in the March issue of Mechanical Engineering, the one by Mr. Funk appears in the present issue, while Mr. Leitch's will be published in a future issue with an abstract of the discussion on the three papers.

Textile Session

UNDER the auspices of the Textile and Management Divisions of the A.S.M.E. one of the sessions of the Providence meeting, held on Wednesday morning, May 5, was devoted to textile and management problems. Joseph A. Campbell, Chairman of the Textile Division, was in charge of the session. The papers presented at this session were: Fundamental Measurements in a Cotton Mill, A General Discussion, by Sidney S. Paine,[30] Engineering Aspects of Treating Textile Water Supplies, by Howard L. Tiger,[31] and Mechanical and Material Research in Management, by Thayer P. Gates.[32] The papers by Messrs. Paine and Tiger will be found in the May, 1926, issue of Mechanical Engineering, and that by Mr. Gates will be found in this present issue.

In discussing the paper by Mr. Paine, Eugene Szepesi[33] proposed the organization by the Textile Division of machinery for recording and dispensing information relating to the technical and engineering aspects of the textile industry.

Chas. T. Main[34] wrote that he had made a practice of gathering for his own use information of a fundamental nature which came to his attention as an engineer engaged by textile companies. He hoped for a coöperation among textile research organizations for the good of the industry.

H. P. Kendall[35] told of his experiences in trying to introduce into the textile industry business methods which had been employed in other lines, and of the difficulty of overcoming the rule-of-thumb practice which he found to be typical of all parts of the industry.

J. A. Willard[36] spoke of similar experiences and in favor of research and standardization in the industry.

McRea Parker[37] said that there was twice as much textile machining as was needed for the demand for textiles, and endorsed the recommendations of Messrs. Szepesi and Main for coöperative research.

McRea Parker, D. H. Marble, W. S. Wheeler, C. S. Makepeace, Horace G. Killam, F. N. Speller, and C. R. Texter contributed to the discussion of Mr. Tiger's paper. The limits set for the present account will not permit an adequate treatment of this rather technical discussion. It will therefore appear in a later issue of Mechanical Engineering.

The discussion of the paper by Mr. Gates took the form of questions to which the author gave answers. Because of its highly technical nature and because of lack of space, this discussion is omitted from the present account of the meeting.

The Memoir on the Flow of Water in Pipes, by the late Hiram F. Mills, mention of which was made in our May issue, forms one of the series of memoirs published by the American Academy of Arts & Sciences, Newbury Street, Boston, Mass., price, $7.50.

[30] President, Textile Development Co., Boston, Mass. Mem. A.S.M.E.

[31] Engineer, Permutit Co., New York, N. Y. Assoc. A.S.M.E.

[32] Textile Specialist and Consulting Engineer, Providence, R. I. Mem. A.S.M.E.

[33] Szepesi Industrial Organization, 320 Broadway, New York, N. Y. Mem. A.S.M.E.

[34] Engineer, Boston, Mass. Mem. A.S.M.E.

[35] Kendall Mills, Inc., Boston, Mass. Mem. A.S M.E.

[36] Treasurer, Bigelow, Kent, Willard & Co., Boston, Mass. Mem. A.S.M.E.

[37] Cleveland Worsted Mills, Cleveland, Ohio. Assoc-Mem. A.S.M.E.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCELEROMETERS

Automobile Testing. Riding-Qualities. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 248–251, 7 figs. Instruments for measurement of riding qualities; recent developments in contact accelerometers; battery of cells versus single adjustable cell; diaphragm; micrometer types of contact accelerometer; dynamic tests; applications.

ACCIDENT PREVENTION

Economic Social Aspect. Does Accident Prevention Pay? G. A. Orth. Safety Eng., vol. 51, no. 3, Mar. 1926, pp. 145–150, 2 figs. Author contends that accident prevention, like production, is business proposition, and as such, should demand and obtain equal consideration.

Eyes. Saving the Eyes of the Worker, S. DeHart. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 253–256, 4 figs. Reviews results of ten years of industrial eye work.

AERONAUTICAL INSTRUMENTS

Types. New Types of Aircraft Instruments, F. L. Hunt. Optical Soc. of Am. & Rev. of Sci. Instruments—Jl., vol. 12, no. 3, Mar. 1926, pp. 227–269, 40 figs. Details of altitude instruments, including barometers and altimeters, precision barograph, etc.; speed instruments, including electric air-speed indicator, ground-speed indicators, rate-of-climb indicators, and recorders, etc.; orientation instruments, including compasses, electric turn indicators and inclinometers; engine, navigation and special instruments and accessories; research problems.

AIR

Viscosity. The Effect of Temperature on the Viscosity of Air, F. A. Williams. Roy. Soc.—Proc., vol. 110, no. A753, Jan. 1, 1926, pp. 141–167, 3 figs. Coefficient of viscosity of dry air free from CO_2 has been studied by means of comparative method of transpiration from 15 to 1002 deg. cent.; results show Sutherland's formula for temperature coefficient of viscosity to hold with great accuracy between 250 and 1000 deg. cent.; value of carbon falls off as temperature decreases and Sutherland's law is no longer true.

AIR CONDITIONING

Humidity Chart. A New Psychrometric or Humidity Chart, C. A. Bulkeley. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32, no. 4, Apr. 1926, pp. 237–244, 3 figs. Fundamental principles underlying subject on which any psychrometric chart or tables must be based; presents Bulkeley chart based on Carrier's rational psychrometric formula; examples in use of chart.

Humidity Control in Textile Mills. Importance of Fixed Regulation of Humidity in the Textile Industry (Die Bedeutung einer bestimmten Regulierung der Feuchtigkeit in den textiltechnischen Betrieben), J. Obermiller. Zeit. für angewandte Chemie, vol. 39, no. 2, Jan. 14, 1926, pp. 46–51, 1 fig. Points out importance of maintaining degree of atmospheric moisture which will remain constant within certain limits, especially in dyeing and textile-printing plants, and in spinning and weaving mills.

AIRCRAFT

Pressure-Distribution Measurement. The Spacing of Orifices for the Measurement of Pressure Distributions, M. M. Munk. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 230, Jan. 1926, 48 pp., 10 figs. on supp. plates. General considerations governing spacing of pressure orifices; spacing along line with constant weight and without structural restrictions; graphical and numerical integration; spacing for special types of pressure distribution; tables for pressure distribution around circle.

AIRPLANE ENGINES

A.D.C. Nimbus. The A.D.C. "Nimbus" Engine. Flight, vol. 18, no. 9, Mar. 4, 1926, pp. 122–126, 14 figs. Designed to fit standard Puma bearers, but differing from Puma considerably in design.

Air-Cooled. Removable Cylinders Simplify Maintenance of Air-Cooled Airplane Engines, A. Black. Automotive Industries, vol. 54, no. 12, Mar. 25, 1926, pp. 528–531, 4 figs. Cylinders may be removed singly for overhauls if desired; parts-replacement cost varies from 5 to 7 per cent of initial cost of engine per 100 hours of actual operation.

American Development. Modern American Aircraft Engine Development, C. L. Lawrence. Aviation, vol. 20, nos. 11 and 12, Mar. 15 and 22, 1926, pp. 364–367, and 411–415, 12 figs. Engineering considerations which have led to designs in question; includes table of engine data covering all engines now in general use or shortly to be in production in United States; chief water-cooled types, valve arrangements; cylinder construction; piston-rod construction and piston cooling; air-cooled engines; cylinder experiments; supercharger installation; radial engines; American light-plane engine.

Bristol Cherub. The Bristol Air-Cooled Engine. Aviation, vol. 20, no. 15, Apr. 12, 1926, pp. 555–556, 2 figs. Details of engine which has been submitted successfully to latest British Air Ministry 100-hr. type tests; it is 2-cylinder opposed type and has total swept volume of 1230 cu. cm.

Design Trend. The Trend of Aircraft Engine Development, E. E. Wilson. Am. Soc. Naval Engrs.—Jl., vol. 38, no. 1, Feb. 1926, pp. 130–143, 5 figs. In summarizing United States Navy's aircraft engine development, it is found that ideas are now crystallized around line of 3 sizes of aircraft engines of 800, 1200 and 1600-cu. in. capacities, which will apparently meet immediate needs of high-performance aircraft for naval aviations.

Manufacture. Aero Engine Manufacture. Machy. (Lond.) vol. 27, no. 703, Mar. 18, 1926, pp. 793–806, 30 figs. Methods employed by Armstrong Siddeley Motors, Coventry, on the Jaguar and Lynx engines.

Speed Reducer. French Airplane Speed Reducing Gear to be Used Here, W. F. Bradley. Automotive Industries, vol. 54, no. 14, Apr. 8, 1926, p. 615, 2 figs. Farman airplane-propeller reducing gear of epicyclic type, at present being used on Farman commercial-airplane engines.

Superchargers. Description and Laboratory Tests of a Roots Type Aircraft Engine Supercharger, M. Ware. Nat. Advisory Committee for Aeronautics—Report, no. 230, 1926, 13 pp., 13 figs. Describes supercharger and presents results of tests made at Langley Field laboratories; supercharger was constructed largely of aluminum weighing 88 lb. and arranged to be operated from rear of standard aircraft engine at speed of $1^1/_2$ engine-crankshaft speed.

Torsional Vibration. Torsional Vibration, B. C. Carter and A. Swan. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 86–88, 1 fig. Notes in connection with crankshaft-airscrew systems; enumerates general conclusions reached in respect of multi-crank engines and outlines simple method of determining frequency of natural vibration in particular cases.

AIRPLANE PROPELLERS

Kirsten-Boeing. Kirsten-Boeing-Propeller (Kirsten-Boeing Propeller), H. Sachse. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 1, Jan. 14, 1926, pp. 1–4, 12 figs.; also translation in Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 351, Feb. 1926, 8 pp., 12 figs. on supp. plates. New means of propulsion for both aerial and marine craft, differing completely from conventional screw propeller, invented by F. K. Kirsten, German-American professor at Univ. of Wash., with aid of American airplane manufacturer, W. E. Boeing; advantages consist essentially in adjustability of thrust in any desired direction, in plane perpendicular to axis of rotation of system, and in its high efficiency; it resembles paddle wheels used on river steamers, differs, however, in that all blades work simultaneously in fluid medium (air or water).

Tests. Comparison of Tests on Air Propellers in Flight with Wind Tunnel Model Tests on Similar Forms, W. F. Durand and E. P. Lesley. Nat. Advisory Committee for Aeronautics—Report, no. 220, 1926, 29 pp., 29 figs. Results of full-scale tests made on five propellers in combination with VE-7 airplane and Wright E-4 engine, and of model tests carried on at aerodynamic laboratory of Stanford University.

Thrust Distribution. The Best Thrust Distribution for Airplane Propellers Taking Profile Resistance into Consideration (Die günstigste Schubverteilung für die Luftschraube bei Berücksichtigung des Profilwiderstandes), T. Bienen. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 1, Jan. 14, 1926, pp. 4–6, 2 figs. Corrected reprint of portion of author's article published in nos. 10 and 11, May 28 and June 13, 1925, issues of same journal, which contained error in one of the equations.

AIRPLANES

Autogiro. De la Cierva's Autogiro (Ueber den Autogyro von de la Cierva). Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 4, Feb. 27, 1926, pp. 69–73, 10 figs. Discusses aerodynamic characteristics of autogiro, or airplane with rotating wings, which were determined in wind tunnel of Quatro Vientos Laboratory in Madrid, and have since been verified in actual flight, although improvements are still needed; to develop flying ability of machine it was necessary to join wings flexibly to central shaft; centrifugal force of wings balances lift; wings can therefore be made very weak; starting at present is somewhat slow.

Bristol Fighter. A Comparison of Model and Full Scale Performance of the Bristol Fighter Using Flight Lieut. Capon's Method of Presentation, E. F. Relf. Aeronautical Research Committee—Reports & Memoranda, no. 983, Sept. 1925, 3 pp., 2 figs. It appears that performance as predicted from 1/5-scale model experiments and measured full-scale performance are in agreement within accuracy of measurement.

Buhl-Verville. The Buhl-Verville Airster CW-3. Aviation, vol. 20, no. 14, Apr. 5, 1926, p. 505, 2 figs. Machine for passenger carrying, light-freight carrying, aerial photography, crop dusting and training; arrangements are provided whereby almost any power plant between 100 and 200 hp. may be installed; wings can be folded back in 12 or 15 minutes.

Duralumin. Duralumin Construction on Original Lines. Flight, vol. 18, no. 10, Mar. 11, 1926, pp. 139–141, 2 figs. Methods employed at works of Short Bros., Rochester, England.

Flying Boats. See FLYING BOATS.

Fokker. The Fokker Commercial Airplanes. Aviation, vol 20, no. 14, Apr. 5, 1926, pp. 512 and 514, 2 figs. Details of Universal and F VII types.

The Three-Engined Fokker (Das dreimotorige Fokker-Verkehrsflugzeug), A. Gymnich. Motorwagen,

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

vol. 29, no. 6, Feb. 27, 1926, pp. 129–131, 4 figs. New monoplane equipped with three Wright air-cooled radial engines of 200 hp. each; wings are entirely self-supporting, that is, internally trussed, and are fastened almost immediately above fuselage by means of four bolts; wings are covered with plywood; speed, 106 mi. per hour; climbing speed is 1000 m. in 4 min., and ceiling, 15,600 ft.

Joints and Fittings. Aeroplane Joints and Fittings, F. M. Green. Flight (Aircraft Engr.), vol. 18, no. 12, Mar. 25, 1926, pp. 178f–178h, 4 figs. Discusses welding by acetylene blow pipe or by various electrical methods; brazing, silver-soldering or soft soldering; and by mechanical joints, that is, by bolting and riveting.

Mail. Stout Air Transport Plane. Aviation, vol. 20, no. 14, Apr. 5, 1926, pp. 506 and 508, 2 figs. Six-passenger cabin design with pilot's cockpit under leading edge of large cantilever monoplane wing.

The Aerial Mercury Air Mail Plane. Aviation, vol. 20, no. 14, Apr. 5, 1926, pp. 508D and 510, 2 figs. Biplane, having no stagger, horizontal top wing and 1½-deg. dihedral on lower wing; one pair of outer struts and Clark-Y wing section; describes also Mercury Jr, all-purpose plane, designed for high performance, low initial and maintenance cost.

The Curtiss Carrier Pigeon and Lark. Aviation, vol. 20, no. 14, Apr. 5, 1926, pp. 502–503, 2 figs. Biplane having exceedingly deep body which carries half-ton of mail (40,000 letters) or parcel post or express packages.

Metal Structure. Relationship of Metallurgy to the Development of Aircraft, J. B. Johnson. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 517–538, 13 figs. Development of metal structure of airplane in United States and various types made and used on European continent, especially in Germany and France during the war; sets forth wide variation in physical properties and chemical analyses of materials used and points out that actual saving of weight has been accomplished by introduction of metal fuselage.

Pander. The Pander Light Biplane. Flight, vol. 18, no. 13, Apr. 1, 1926, pp. 192–194, 6 figs. School 2-seater with 45-hp. Anzani engine.

Parachutes. See PARACHUTES.

Remington-Burnelli. The Remington-Burnelli Airliner. Aviation, vol. 20, no. 14, Apr. 5, 1926, p. 506, 1 fig. Twin-engine machine, with fuselage of duralumin; wing consists of box-type duralumin girders with lattice webs.

Seaplanes. See SEAPLANES.

Slipstream Effect. Slip Stream Effect, C. N. Montieth. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 355, Mar. 1926, 7 pp., 4 figs. Horizontal tail surfaces of new airplane are proportional so that curve of moment about center of gravity, combined with similar curve for wings alone, gives composite curve which provides certain specified degree of static stability.

Spinning. Some Experiments on a Model of a B.A.T. "Bantam" Aeroplane with Special Reference to Spinning Accidents, H. B. Irving, A. S. Batson, H. C. H. Townend and T. A. Kirkup. Aeronautical Research Committee—Reports & Memoranda, no. 976, Nov. 1925, 21 pp., 17 figs. Results of investigation made in search for direct explanation of accidents due to non-recovery from spin, and in pursuance of general research on spinning; longitudinal control and rolling experiments; experiments on forces and moments including rudder control.

Standard Specifications. Report on Work of Standards Committee for Aeronautics of German Industrial Standards Committee (Bericht über die Arbeiten des Fachnormenausschusses für Luftfahrt), M. Lehl. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 1, Jan. 14, 1926, pp. 6–7, 3 figs. Tentative standard sheet for relation between steering and airplane movement, standards for propeller sizes, etc.

Technical Progress. Technical Progress in Aeronautics, E. E. Aldrin. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 309–316, 15 figs. Trend in airplane construction; increasing use of metal in fuselage and wing structures; lighter, more rigid, and more powerful engines; metal propellers; improvements in navigating instruments; roll reduction through braking, etc.

Tests. Some Aspects of the Comparison of Model and Full-Scale Tests, D. W. Taylor. Nat. Advisory Committee for Aeronautics—Report, no. 219, 1926, 23 pp., 19 figs. Author considers general case applying to motion of objects in fluid medium.

Training. The Vickers "Vendace." Flight, vol. 18, no. 11, Mar. 18, 1926, pp. 164–167, 6 figs. Medium-sized tractor biplane intended for training purposes, either as land machine or seaplane.

Udet. The Udet-Kondor (Udet-Kondor), F. Wittekking. Luftfahrt, vol. 30, no. 3, Feb. 5, 1926, pp. 37–38, 2 figs. Details of new commercial plant with duralumin body and wooden wings; 4 air-cooled 9-cylinder Siemens Stern engines of 100 hp. each, two engines suspended from each wing; capacity, eight passengers.

Wings. Tests for Determining the Effect of a Rotating Cylinder Fitted into Leading Edge of an Airplane Wing, E. B. Wolff and C. Koning. Nat. Advisory Committee for Aeronautics—Tech. Memorandums no. 354, Mar. 1926, 15 pp., 8 figs. Experiments performed with wing model to which rotary cylinder had been fitted; rotation of cylinder has remarkable effect on aerodynamic properties of wing; experimental results and theoretical explanation of phenomena; discusses problems still to be investigated and possibilities of practical application. Translated from Rijks-Studiedienst voor de Luchtvaart.

AIRSHIPS

Semi-Rigid. The Goodyear Semi-Rigid Airship "RS-1." Flight, vol. 18, no. 12, Mar. 25, 1926, pp. 175–176, 4 figs. Airship built for U. S. Army Air Service is 282 ft. in length, 70 ft. 6 in. in diameter and has gas volume of 720,000 cu. ft.; powered with 4 low-compression Liberty engines in 2 steamlined power cars located aft and suspended from keel.

ALIGNMENT CHARTS

Construction and Use. Designation, Graphic Development and Use of Alignment Charts (Bemerkungen zur Bezeichnung, zur zeichnerischen Ausgestaltung und zum Gebrauch von graphischen Rechentafeln), P. Werkmeister. Bauingenieur, vol. 7, no. 9, Feb. 26, 1926, pp. 162–165. Discusses kinds of charts and tables, their construction to scale, point scales and curve scales; development of design of charts for effective use.

Mathematical Principles. Mathematical Bases of Most Simple Nomographic Charts, Their Construction and Use in Locomotive Work (Die mathematischen Grundlagen der einfachsten nomographischen Rechentafeln, ihre Herstellung und praktische Anwendung im Lokomotivmaschinenbau), U. Barske. Glasers Annalen, vol. 98, no. 2, Jan. 15, 1926, pp. 17–22, 12 figs. Explains operation of adding and multiplying, and construction of charts; examples of calculating resistance of rolling stock, tractive effort of locomotives.

ALLOYS

Aluminum. See ALUMINUM ALLOY.

Iron. See IRON ALLOYS.

Magnesium. See MAGNESIUM, Properties.

ALUMINUM ALLOYS

Aluminum-Lithium. Aluminum-Lithium Alloys (Ueber vergütbare Aluminium-Lithiumlegierungen), P. Assmann. Zeit. für Metallkunde, vol. 18, no. 2, Feb. 1926, pp. 51–54, 3 figs. Diagram of state of aluminum-lithium system is re-plotted on thermal basis and limit of saturation of mixed crystals is established; hardness and refining capacity of these alloys is examined as well as refining effects of small additions of lithium to aluminum-copper and aluminum-zinc alloys.

Sand-Cast. Properties of Some Sand-Cast Alloys of Aluminium Containing Silicon and Magnesium, S. Daniels. Indus. & Eng. Chem., vol. 18, no. 4, Apr. 1926, pp. 393–398, 14 figs. Effects of addition of silicon in amounts up to 5 per cent magnesium; alloys cast have no outstanding mechanical properties, but in heat-treated condition, because of solubility of silicon and magnesium silicide, they present interesting possibilities; outlines metallographical characteristics of series.

AMMONIA COMPRESSORS

Oil-Engine-Driven. Oil Engine Driven Ammonia Compressors, F. W. Green. Refrig. Eng., vol. 12, no. 9, Mar. 1926, pp. 311–316, 5 figs. Discusses oil-engine driven compressor which has been specially designed for service under consideration; consists of horizontal, double-acting ammonia cylinder driven directly through connecting rod and crosshead by single-cylinder, horizontal single-acting oil engine.

Power-Drive Equipment. Power Drive Equipment for Ammonia Compressors, G. Fox. Indus. Engr., vol. 84, no. 3, Mar. 1926, pp. 106–109, 4 figs. Factors to consider when selecting equipment, including type and capacity of motor required, kind of control apparatus necessary and type of mechanical connection that should be used for coupling motor to compressor.

Speed, Effect of. Effect of Speed on Compressor Capacity and Power, L. H. Jenks. Refrig. Eng., vol. 12, no. 9, Mar. 1926, pp. 291–310 and 316–317, 32 figs. Results of test was to note performance of compressor known to makers as Type J, having plate valves arranged radially to cylinder circumference.

ASH HANDLING

Mechanical. A Recent Development in the Mechanical Handling of Ashes, G. F. Zimmer. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 242–244, 3 figs. Details of system recommended because of its simplicity, long life and efficiency.

AUTOMOBILE ENGINES

Carburetors. See CARBURETORS.

Cycles, Calculation of. Explosion Cycles, Calculation of Efficiency and Heat Balance (Remarques sur les cycles à explosions. Calcul du rendement et du bilan thermique), A. Planiol. Technique Automobile et Aerienne, vol. 16, no. 131, 1925, pp. 97–109, 6 figs. Discusses polytropic curves of explosion engines, variation of specific heats and transmission in walls, temperature of exhaust and quantity of residual gas; numerical calculation of cycles, and of heat balance; cycle of Andreau engine; effect of cylinder dimensions on mean pressure and fuel consumption.

Machining Parts. Machining Automotive Engine Parts, A. Murphy. Can. Machy., vol. 35, nos. 8 and 9, Feb. 25 and Mar. 4, 1926, pp. 14–17 and 15–18, 13 figs. Outstanding features of West Toronto plant of Willys-Overland Co. Feb. 25: Production of cylinder blocks. Mar. 4: Machining of cylinder heads, crankshafts, camshafts, pistons, connecting rods and flywheels.

Manifolds and Oil Pipes, Machining. Willys-Knight Production Methods, F. H. Colvin. Am. Mach., vol. 64, no. 13, Apr. 1, 1926, pp. 513–514, 6 figs. Fixtures and methods used in manufacturing manifolds and oil pipes.

Oil Filters. New Engine Oil Filter Built for Quick Cleaning by Compressed Air. Automotive Industries, vol. 54, no. 13, Apr. 1, 1926, pp. 570–571, 4 figs. Foreign matter collecting in H-W-filtrator can be blown out; new air filter also introduced by Rich Tool Co.

Operating Temperatures. High Average Operating-Temperature and Engine and Car Operation. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 255–267, 17 figs. Part 1, A. Taub: Deals with laboratory tests to prove by comparative data that higher average operating temperature maintained in engine by constant-temperature or evaporation system of cooling have negligible detrimental effects. Part 2, L. P. Saunders: Gives results of road tests of cars operated under same conditions when fitted with standard water-cooling radiator core and with constant-temperature cross-flow condenser core.

Sleeve-Valve. Sleeve-Valve Engines, P. M. Heldt. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 303–314, 15 figs. History of sleeve-valve engine; reviews valve action of Knight engine, discusses combustion-chamber shape and comments upon permissible compression, and carbon deposit in sleeve-valve type of engine; results of endurance tests.

AUTOMOBILE FUELS

Anti-Knock Compounds. Anti-Knock Materials, W. H. Charch, E. Mack, Jr., and C. E. Boord. Indus. & Eng. Chem., vol. 18, no. 4, Apr. 1926, pp. 334–340, 7 figs. Results of investigation to extend knowledge as to what class of compounds may function as anti-knock materials; relationship between suppression of detonation as occurring with acetylene in open tube and as occurring in motors with motor fuels; relationship between detonation and electrical conductivity of burning gases; suggests chemical theory for action of anti-knock materials, based on experimental data thus far bearing on phenomena.

Developments. Present-Day Automotive-Fuel, R. F. Lybeck. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 282–284, 1 fig. Author states present specification for distillation range of gasoline and mentions conditions causing transition from former 400-deg. to present 437-deg. fahr. end point; by eliminating certain components of what is generally considered good gasoline, detonation can be eliminated; new fractionation equipment consisting of novel type of bubble tower that permits very close "cutting" of gasoline for elimination of "borderland" mixture, as well as new process of treatment.

Synthetic. A New Automobile Fuel (Ein neuer Motorbrennstoff). Motorwagen, vol. 29, no. 2, Jan. 20, 1926, p. 35. New synthetic fuel, developed by two Norwegians, Wittke and Selvin, obtained from sulphite alcohol and gas tar as by-product; it can be utilized directly in ordinary gasoline engine and in Norway it is cheaper than gasoline.

Volatility. Progress in the Measurement of Motor-Fuel Volatility, T. S. Sligh, Jr. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 393–496, 2 figs. Laboratory test methods of indicating volatility characteristics and starting capability of fuels used in internal-combustion engines; testing apparatus and procedure.

AUTOMOBILES

American and European Data. Analysis of American and European Automobile Industry (Lehren des amerikanischen und europäischen Automobilbaues), G. Becker. Motorwagen, vol. 29, no. 5, Feb. 20, 1926, pp. 91–106, 17 figs. Review of dynamic data for automobiles the world over, given graphically in convenient form for ready reference; American cars have distinctly fast-running engines when grouped on basis of cylinder volume and numbers of revolution per 100 m.; they are designed with higher gas velocities in valves and carburetors; they do not have as high maximum outputs per unit volume as European engines, and in consequence are less subjected to thermal stresses, can be built cheaper, etc.; points out that German manufacturers must learn to build much lighter cars. See also Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 8 and 9, Feb. 20 and Mar. 6, 1926, pp. 245–252 and 323–326, 18 figs.

Berlin Show. The German Automobile Show (Die Personenwagen auf der Deutschen Automobil-Ausstellung), A. Erkens. Automobil-Rundschau, vol. 28, no. 2, Feb. 1, 1926, pp. 30–38, 18 figs. Tendencies in design of passenger cars; there were only a few departures from conventional design, among which are mentioned: Rumpler streamline car with swinging half axles and engine in rear; small car of Schwäbische Hüttenwerke, which has 2-cylinder engine, opposed, front-end drive, and independent wheels mounted on coil springs; chassis and body are in one piece; Steyr car with independent wheels; many of smaller cars have cylinder blocks of light metal with separate sleeves of steel or cast iron; Hansa-Lloyd shows high-class 8-cylinder car with central lubrication; light-metal pistons preponderate.

Brakes. Air Brakes for Automobiles (Druckluftbremse für Personen-Kraftwagen), Castner. Dinglers Polytechnisches Jl., vol. 341, no. 1, Jan. 1926, pp. 1–4, 7 figs. Design and tests of Knorr air brake with two-stage compressor acting on both axles, which has given satisfaction in exacting trials.

Chassis Design. Modern Chassis-Frame Design and Body Mounting, T. D. Carpenter. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 115–116. Deals with performance vs. weight; silence vs. efficiency; power vs. tax; comfort vs. speed; author considers, from survey of various types of chassis-frame in present day use, whether any basic principles may be deduced which are essential for successful design.

De Dion. The 10–20 H.P. De Dion Car. Auto-Motor Jl., vol. 31, no. 9, Mar. 4, 1926, pp. 185–188, 12 figs. Equipped with 4-cylinder monobloc, side-valve engine with clutch and gear integral, mounted in 3-point suspension in pressed-steel chassis frame upcurved at rear and with sides wide away from each other at rear and tapering towards each other to front; 4-wheel brakes.

Equipment, Operating Costs of. Analysis of Operating Costs of Automotive Equipment, J. Scott. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 367–370, 6 figs. To determine economic life of unit automotive equipment by graph, 3 curves are used, one representing obsolescence and interest on

investment, another chassis repairs and third total cost, or summation of obsolescence and repair costs.

Headlights. Automobile Head-Lamp Light-Characteristics and Improved Distribution, W. D. Ryan. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 351–358, 11 figs. States that headlights glare if they are adjusted for range and that, when adjusted for non-glare they have no range; hence careful tests were made on number of best types of approved headlight and lens in use; it is believed that two-filament lamps will do much to improve present situation; specifications for improved headlights; discussion of tests.

Dipping Headlights. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 96–97, 4 figs. Apparatus designed and produced by Sheffield-Simplex Co.

Headlighting Situation in the District of Columbia, R. E. Carlson. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 399–401. New regulations adopted; educational campaign conducted; as result of these measures night accident percentage was reduced one-half.

Hotchkiss. The 15.9-Hp. Hotchkiss Car. Auto-Motor Jl., vol. 31, no. 8, Feb. 25, 1926, pp. 163–166, 13 figs. Engine, clutch and gear are mounted as complete and compact unit while transmission is in enclosed shaft in torque-resisting tubular extension of back axle; engine is of monobloc type with cylinders 80 mm. in internal diameter; front-wheel braking system.

Rover. The 9-20 H.P. "Super" Model Rover. Auto-Motor Jl., vol. 31, no. 11, Mar. 18, 1926, pp. 227–229, 9 figs. Redesigned 4-cylinder car with wide frame and longer wheelbase; 4-wheel braking system.

Vulcan. The 12 H.P. Vulcan Chassis. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 80–85, 10 figs. Overhead-valve-engine model is typical medium-sized British car; chassis is large enough to accommodate comfortable 4-door saloon body; engine is 4-cylinder proprietary component power being transmitted through cone clutch and 4-speed gear box; brakes are fitted to all four of detachable wire wheels, and reinforced balloon tires are standard.

Worm-Gear Drive. Worm Gear Drive Re-entering American Passenger Car Practice, W. L. Carver. Automotive Industries, vol. 54, no. 11, Mar. 18, 1926, pp. 479–482, 2 figs. Chief advantage offered is possibility of lowering center of gravity; used on British cars of all price classes and has proved both efficient and durable.

AVIATION

Air-Mail Service. Air Mail Service, W. I. Glover. Aviation, vol. 20, no. 14, Apr. 5, 1926, pp. 488–489, 2 figs. Developments of United States Air Mail Service; specialized planes developed. See also accounts of various air-mail routes as follows: Chicago to Dallas Air Mail Line, pp. 490–491, 2 figs.; Ford Air Transport, p. 492; Los Angeles–Salt Lake City Air Mail Line, H. M. Hanshue, pp. 493–494, 1 fig.; Los Angeles–San Diego Airline, pp. 495–496, 2 figs.; Washington, Oregon, Idaho Air Mail, pp. 496–497, 1 fig.; Boston–New York Air Mail Line, pp. 498–499, 1 fig.; Chicago–St. Louis Air Mail Line, p. 499; Chicago–St. Paul Minneapolis Air Mail, pp. 500–501, 2 figs.; Seattle–San Francisco Air Mail Line, p. 501.

Airway Lighting. The Lighting of the London Continental Airway, C. H. Biddlecombe. Aviation, vol. 20, no. 15, Apr. 12, 1926, pp. 550–552, 2 figs. Night-flying system employed on Imperial Airways Route from London to Continent.

Commercial. Fundamental Requirements for Commercial Aviation. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 385–387. Discussion of paper by W. B. Stout, published in Nov. 1925, issue of journal. See reference to original article in Eng. Index 1925, p. 64.

Flying-Field Equipment. Flying Field Equipment for Air Transport, A. Black. Aviation, vol. 20, no. 15, Apr. 12, 1926, pp. 553–554, 4 figs. Elements affecting equipment; type of hangar buildings; internal equipment; gasoline storage and equipment.

B

BALANCING MACHINES

Martin. Martin Balancing Machine. Machy. (Lond.), vol. 27, no. 704, Mar. 25, 1926, pp. 842–843, 2 figs. Machine affords quick, inexpensive and accurate method of balancing rotary bodies such as armatures, rotors, gear wheels, propellers, fans, disks, crankshafts, etc.

BEARINGS

Tests. Testing Bearings (Ueber Lagerversuche), V. and R. Vieweg. Maschinenbau, vol. 5, no. 5, Mar. 4, 1926, pp. 201–206, 7 figs. Effect of heat due to friction on excess temperature of test bearings, and its elimination by cooling; calorimetric method for separating air and bearing friction; frictionless loading of shafts; example of test with ball bearings.

BEARINGS, BALL

Loads. Calculating Maximum Load for Ball Bearings and Testing Steels Suitable for Ball Bearings (Die Berechnung der im Kugellager auftretenden Grösstbeanspruchung und die Prüfung von Stählen, die für den Kugellagerbau geeignet sind), O. Föppl. Montanistische Rundschau, vol. 17, no. 18, Sept. 16, 1925, pp. 597–602, 5 figs. Calculation of loads by means of Hertz's formulas on elastic displacement; uniformity of ball-bearing steel; vibration test.

BEARINGS, ROLLER

Tapered. The Tapered Roller Bearing in Industry, A. P. Strong. Belting, vol. 28, no. 2, Feb. 1926, pp. 32 and 34. Fulfills all requirements of anti-friction bearing for machine tools; machinery applications requiring low speeds, high speeds and shock loads.

BOILER FEEDWATER

Conditioning. Boiler-Water Conditioning with Special Reference to High Operating Pressure and Corrosion, R. E. Hall. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 317–325 and (discussion) 325–327, 17 figs. Prevention of scale formation on evaporating surfaces; relation between chemical used and operating pressure; prevention of corrosion of surface in contact with boiler water; control of non-condensable gases in steam by boiler-water conditioning.

Heating and Deaerating. Feed Water Heating Deaerating and Pumping Plant. Eng. & Boiler House Rev., vol. 39, no. 9, Mar. 1926, pp. 411–426, 18 figs. Deals with handling of feedwater, that is, pumping into boiler circuit, deaerating or degassing to get rid of dissolved air in apparatus forming part of this circuit as distinct from ordinary softening plant and feed heating by means of exhaust steam that may be available.

Treatment. Preparation of Feed Water in Modern Power Houses, Von Le Juge. Eng. Progress, vol. 7, no. 3, Mar. 1926, pp. 64–67, 5 figs. Recent design of evaporating plants; deals with supplementing and degasing feedwater.

Purification of Boiler Feedwater (Die Reinigung des Kesselspeisewassers), P. Wiegleb. Wärme- u. Kälte-Technik, vol. 28, no. 4, Feb. 15, 1926, pp. 37–39. Chemical, thermal, permutite and vacuum processes; evaporation, deaeration and distillation; recommends adoption of process suitable to composition of water.

BOILER FURNACES

Air Preheaters. The Perry Air Heater for Boiler Furnaces. Engineering, vol. 121, no. 3144, Apr. 2, 1926, pp. 445–447, 5 figs. Simple and effective form of air heater, which, although primarily intended for preheating air delivered to boiler furnaces, can also be used for obtaining supply of hot air for drying and other industrial processes; designed by H. H. Perry.

Combustion Chambers. Combustion Chambers for Pulverized Coal Firing, L. C. Harvey. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 104–106, 4 figs. Forecast of future developments in combustion-chamber designs for burning of cheaper grades of fuel in pulverized form under industrial boilers and in smaller types of metallurgical or process furnaces.

Draft Regulators. Automatic Furnace Regulators (Selbsttätige Feuerungsregler), Berner. Wärme, vol. 49, no. 1, Jan. 1, 1926, pp. 1–5 and (discussion) 5–7, 6 figs. Details of Roucka draft regulator which employs membrane exposed to pressure variations in steam main to operate, through system of levers, valves of a servo-motor which adjusts damper as required; one lever has adjustable fulcrum so that setting of gear can be varied, and any given total demand for steam divided as required between different boilers; whole system is kept automatically in slow vibration so as to eliminate effects of friction as completely as possible; it is claimed that regulator will adjust draft within 1/500th of an inch water gage; other forms of automatic regulators are described in discussion.

Grate Bars. Recent Tests with Grate Bars (Neuere Versuche mit Roststäben), Schulz. Brenstoff- u. Wärmewirtschaft, vol. 8, no. 2, Jan. 2, 1926, pp. 22–25, 7 figs. Experience with use of hollow grate bars cooled by air or steam; results of tests with dumping and step grates; protection against corrosion by first applying a thin temporary coating of aluminum to bar in cold state to prevent oxidation, and then heating bar to about 800 degrees, after which final and permanent aluminum coating is applied.

Mechanical Firing. The Mechanical Firing of Solid Fuel, A. W. Bennis. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 67–73, 4 figs. Describes most efficient and economical method in use.

BOILER OPERATION

Draft. Theory of Induced Draft and Suction Draft Apparatus (Théorie des appareils à tirage induit et à tirage aspiré total), F. Prothais. Chaleur et Industrie, vol. 6, nos. 68 and 70, Dec. 1925, and Feb. 1926, pp. 555–561 and 91–96, 4 figs. Discusses forced draft and induced draft, determination of fans and their operation and efficiency. Theory of suction-draft apparatus, comparison of both systems.

BOILER PLANTS

Instruments. The "Bailey" Boiler Meter. Machy. Market, no. 1323, Mar. 12, 1926, pp. 25–26, 2 figs. Purpose of meter is to serve as reliable guide for fireman in showing him exactly what conditions are at every instant, and furnishing him with necessary information for correcting bad conditions as soon as they occur.

Steam Separators. Steam Separators (Dampftrockner), L. Heuser. Wärme, vol. 49, no. 9, Feb. 26, 1926, pp. 150–153, 8 figs. Water carried in suspension by steam leaving boiler results in heat losses and more or less serious operating troubles; author shows that higher first cost of really effective steam separators is fully justified by savings which they effect; apart from saving in heat, there is great reduction in wear on cylinder walls and turbine blades by elimination of solids carried in wet steam; enumerates principal requirements to be fulfilled by steam separator, and compares three different types in regard to their constructional features and action.

BOILERS

Design. Boilers and Furnaces, A. Grounds. Indus. Mgmt. (Lond.) (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 62–66, 3 figs. Construction and operation of most efficient types of boilers and furnaces used in modern power plants.

Developments. Increased Efficiency and Progress in Boiler Construction (Leistungssteigerung und Fortschritte im Dampfkesselbau), C. Rühl. Wärme u. Kälte-Technik, vol. 28, nos. 2 and 3, Jan. 15 and Feb. 1, 1926, pp. 9–14 and 23–28, 22 figs. Discusses improvements in furnace construction, pulverized-coal firing and pulverizers, high-pressure boilers; design and operation of Oschatz and Humbolt vertical-tube boilers; maximum-pressure boilers by Borsig (60 atmos.), Hanomag (100 atmos.), Atmos and Benson types, etc.

Electric. The Generation of Explosive Gases in Electric Water Heaters and Boilers. Elec. News, vol. 35, no. 4, Feb. 15, 1926, pp. 27–30 and 51, 1 fig. Operating on alternating current with submerged electrodes, introduces danger factor; interesting experiments in Winnipeg.

Gas-Fired. Town's Gas for Steam Generation, J. N. Williams. Gas World, vol. 84, no. 2173, Mar. 13, 1926, pp. 247–251, 4 figs. Details of Bonecourt System; Spencer-Bonecourt boiler is constructed of mild steel plates tested to British standard specification, tube plates being flanged with ample radius to meet shell; gas burner is independent of and external to boiler; it consists of cast-iron header to which gas main is connected and from which burners rise. (Abstract.) Paper read before Midlands District Salesman's Circle.

High-Pressure. First Superpressure Plant in Germany (Die erste Höchstdruckdampf-Betriebsanlage in Deutschland), Wempe. Elektro-Jl., vol. 5, no. 24, Dec. 25, 1925, pp. 447–450, 9 figs. Details of Borsig vertical-tube boiler, of 60-atmos. working pressure, showing same coal consumption for equal quantities of steam at 60 atmos. and 425 deg. cent. as for 12 atmos. and 390 deg.; test data.

Steam Plants of Very High-Pressure (Dampanlæg med meget hoje tryk) Ingeniören, vol. 35, no. 1, Jan. 1, 1926, pp. 1–6, 5 figs. Discusses developments leading up to, and including first 60-atmos. Schmidt boiler with test data of latter; also test data of 100-atmos. boiler in Sweden and its application in other countries; Löffler boiler of 100 atmos. at Vienna locomotive shops; design and operation.

Inspection. Inspecting Boilers in England, A. Wrench. Boiler Maker, vol. 26, no. 4, Apr. 1926, pp. 107–108. Advisability of adopting definite procedure when inspecting boilers of different types; suggested procedure to follow.

Internal-Combustion. The Internal Combustion Boiler, O. Brunler. Inst. Mar. Engrs.—Trans., Feb. 1926, pp. 625–640 and (discussion) 640–663, 5 figs. Considers possibilities of reducing heat losses in boiler; idea in working of internal-combustion boiler, principle of which is to maintain flame burning in water in order to produce steam for power or heating purposes; discusses flame temperature, what becomes of gases produced during combustion; compressor question, condensation, etc.; practical example demonstrating what can be gained with Brunler boiler, showing how it is possible to reduce steam power.

Locomotives. See LOCOMOTIVE BOILERS.

Low-Pressure. Low-pressure Boiler Plants (Beobachtungen an Niederdruckkessel-Analgen), M. Klein. Zeit. Bayerischen Revisions-Vereins, vol. 30, no. 4, Feb. 28, 1926, pp. 37–42, 7 figs. Discusses boilers with automatic return of water of condensation, and boilers for producing steam for manufacturing purposes, their designs and defects, especially as they are not subject to regulations like high-pressure boilers.

Oil-Fired. Oil-Fired Yarrow Land-Type Boiler. Engineer, vol. 141, no. 3662, Mar. 5, 1926, pp. 274–275, 1 fig. Boilers of single gas-flow type equipped for oil burning.

Riveted Joints. British Boiler Shop Practice, F. J. Drover. Boiler Maker, vol. 26, no. 4, Apr. 1926, pp. 111–113, 9 figs. Board of Trade requirements for riveted joints and calculation of their efficiencies.

Scale Removal. Boiler-Scale Prevention by Means of Kespurit (Kesselsteinverhütung mittels Kespurit), E. Awe. Archiv für Wärmewirtschaft, vol. 7, no. 3, Mar. 1926, pp. 85–87. Tests in open vessels of glass and of iron and tests in pressure vessels, showing that Kespurit is based on physical and not on chemical phenomena and it has no detrimental action; its use is very simple and particularly adaptable to cases where chemical water purification cannot be safely carried out.

Spheroidal State. The Spheroidal State in Steam Boilers (La Caléfaction et la limite de production des générateurs de vapeur), E. Emanaud. Revue Industrielle, vol. 56, no. 2199, Feb. 1926, pp. 68–74, 5 figs. Explains physical nature and conditions of so-called spheroidal state, in which water is held out of contact with hot surface (at temperature above boiling point) by intervening layer of steam; latter greatly increases resistance to heat transmission between hot surface and water; there is serious risk of plate being weakened by overheating to which it is subjected or damaged by sudden contraction; to obviate these risks, it is suggested that inner surface of plates should be covered with thin layer of very fine crystalline points, metallic or non-metallic; water could not assume or maintain spheroidal state over such a surface. See also brief translated abstract in Power Engr., Mar. 1926, p. 113.

Vertical. New Tests with Sectional Vertical Tube Boilers of Mass Type (Neue Versuche am Sektional-Steilrohrkessel Bauart Maas), F. Kaiser. Zeit. des Bayerischen Revisions-Vereins, vol. 30, nos. 1 and 2, Jan. 15 and 31, 1926, pp. 1–6 and 17–20, 2 figs. Test boilers built by Babcock and by M.A.N., results of tests on basis of upper and lower calorific values; distribution of heat over heating surfaces; coefficient of heat transmission; concludes that Maas boilers combine high performance and efficiency.

BOILERS, WATER-TUBE

Field. Defects of the Field Tube Boiler and Their Elimination (Mängel des Fieldrohr-Dampfkessels und

deren Beseitigung), A. Schneider. Archiv. für Wärmewirtschaft, vol. 7, nos. 1 and 3, Jan. and Mar. 1926, pp. 11–15 and 70–74, 30 figs. Author seeks to show that defects of Field boilers can be overcome by simple means; tests of water circulation; use of new heating element for superpressure boilers.

Heat Losses. Radiation and Conduction Losses of Water-Tube Boilers in State of Resistance, during Feeding and Stops (Strahlungs- und Leitungsverluste und Wasserrohrkesseln im Beharrungszustande, während des Einlaufens und in den Betriebspausen), E. Praetorious. Archiv für Wärmewirtschaft, vol. 6, no. 11, Nov. 1925, pp. 285–288, and vol. 7, nos. 1 and 3, Jan. and Mar. 1926, pp. 18–23 and 71–80, 14 figs. Test of boiler plant at full and half loads to determine losses; shows that complete state of resistance is not reached in 8-hr. operation; to radiation and conduction losses must be added losses due to internal cooling. Means of reducing radiation and conduction losses; insulation of surfaces; reduction of stored heat.

High-Pressure. High-Pressure Water-Tube Boilers for Marine Purposes, H. E. Yarrow. Engineering, vol. 121, no. 3144, Apr. 2, 1926, pp. 443–445, 6 figs. partly on p. 434. Investigates practical application of high pressure and temperatures on board ship with special reference to definite step which has been taken in introducing high-pressure boilers in passenger steamer under construction. Paper read before Instn. Nav. Architects.

Maintenance and Operation. The Maintenance and Operation of High Pressure Water Tube Boilers, F. J. Drover. Indus. Mgmt. (Lond.), vol. 13, no. 3, Mar. 1926, pp. 146–148. Notes on firing and regulation of draft plates; feeding; care of boilers after use; industrial management.

Three-Drum Type. Recent Modifications to Water-Tube Boilers of the Three-Drum Type in H. M. Navy. Engineering, vol. 121, no. 3145, Apr. 9, 1926, pp. 478–480, 8 figs. Results of experiments carried out to ascertain if it were possible to stiffen water drums of this shape sufficiently to prevent distortion taking place under normal pressure.

BRAKES

Air. Some Fundamentals of the Air Brake, J. C. McCune. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 223–226. Braking problems of modern freight and passenger-train operation. (Abstract.) Paper read before Eastern New York Section of Am. Soc. Mech. Engrs.

Cast-Iron Shoes. Comparative Tests of Cast Iron Brake Shoes, F. H. Williams. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 209–211, 6 figs. Shoes having expanded metal insert are found to give more economical service.

BRASS

High-Strength. High Strength Brasses. Metallurgist (Supp. to Engineer, vol. 141, no. 3661), Feb. 26, 1926, pp. 20–21. Discusses ternary systems containing copper and zinc with aluminum, iron, nickel and manganese respectively; deals solely with castings; complex alloys.

BRONZES

Genelite. Characteristics of Genelite. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 647. Genelite is spongy bronze having approximately 40 per cent by volume of graphite mechanically mixed with it; use for bearing metal and for valve facings. Reference-book sheet.

C

CABLES, HOISTING

Calculation. Loading of Stranded Cable (Die Beanspruchung der Litzenseile), P. Stephan. Fördertechnik u. Frachtverkehr, vol. 19, no. 2, Jan. 22, 1926, pp. 14–17, 1 fig. Discusses angle of stranding, stress distribution in purely axial loading, maximum stresses, bending formula, and tests necessary for proper calculation.

CABLEWAYS

Austria. Building the Zugspitz-Line (Der Bau der Zugspitzbahn), Findels. Zeit. des Oesterr. Ingenieur- u. Architeken-Vereines, vol. 78, no. 1/2, Jan. 8, 1926, pp. 6–9, 10 figs. Details of cableway in course of construction to top of Mount Zugspitz 3380 m. in length, rising 1581 m.; cables have a breaking strength of 176,000 kg. of which only 44,000 kg. are used; towers, stations and general construction work.

CALORIMETERS

Oxygen-Bomb Determination. Theoretical and Recorded Pressures in Oxygen Bomb Determinations, M. J. Bradley, C. Z. Rosecrans and R. M. Corbin. Indus. & Eng. Chem., vol. 18, no. 3, Mar. 1926, pp. 307–309, 3 figs. Measurement and photographic records of pressures with oxygen bomb during combustion of different weights of crude petroleum, colas, benzene, kerosene and benzoic acid.

Repair and Maintenance. Car Lighting at the Kansas City Terminal, W. J. Dawson. Ry. Elec. Engr., vol. 17, no. 3, Mar. 1926, pp. 75–80, 10 figs. System of recording time and materials used in maintaining various equipments.

Suburban Coaches. Suburban Coach Lighting on the B. & M., P. J. Callahan. Ry. Elec. Engr., vol. 17, no. 3, Mar. 1926, pp. 67–69, 6 figs. Turbo-generator mounted on boiler top furnishes lighting current for locomotive and train.

CARBURETORS

Adjusting. Correct Carburetor Adjustment and Improper-Adjustment Effects, O. H. Ensign. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 389–391. After discussing conditions that control power output, general method of adjustment that can be applied with certainty to any installation is presented.

CAST IRON

Melting with Alkali Flux. Refine Iron with Alkali Flux, G. S. Evans. Foundry, vol. 54, no. 5, Mar. 1, 1926, pp. 180–183 and 187, 6 figs. Details of operation and results obtained in using alkali flux in melting foundry iron. (Abstract.) Paper read before Detroit Foundrymen's Assn.

Shrinkage. Shrinkage and Stresses in Cast Iron (Schwindung und Spannung im Gusseisen), E. Bauer. Giesserei-Zeitung, vol. 23, nos. 3, 4 and 5, Feb. 1, 15 and Mar. 1, 1926, pp. 61–73, 95–102 and 121–128, 77 figs. Effects of shrinkage dependent upon type, shape and strength of casting; means of preventing ill effects accompanying shrinkage; approximate predetermination of size and nature of stresses with aid of shrinkage curves; practical examples.

CASE-HARDENING

Copper Migration in. Copper "Migration" in Carburizing, E. H. Stilwell. Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 323–325. Tells how large automobile manufacturing company overcame difficulty of mon-uniform carburization of camshafts; trouble was due to what has been called copper migration, which is believed to be caused by presence of lead in carburizing compound; discusses two methods used for manufacture of camshafts.

Nitration Hardening. The Krupp Process of Nitration Hardening (Das Nitrierhärtungsverfahren der Fried. Krupp Aktiengesellschaft), A. Fry. Kruppsche Monatshefte, vol. 7, Feb. 1926, pp. 17–24, 16 figs. Comparison of nitration hardening with ordinary case-hardening; main advantage of process for machine parts is that they can be hardened after finishing without distortion; objects are exposed to nitrogen at temperature of less than 580 deg. cent.; no quenching is required to develop surface hardness; nitration is applicable only to certain kinds of alloy steels manufactured by Krupp, but do not differ greatly from ordinary chrome and chrome-nickel steels; process is recommended for gears, journals and bearings, shaft and crankshafts, small parts for typewriters, etc.; roller-chain parts, guides; tool parts, gages, etc. See also Maschinenbau, vol. 5, no. 4, Feb. 18, 1926, pp. 161–165, 12 figs.

Solid Cements. Carburization by Solid Cements, W. E. Day, Jr., Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 240–257 and (discussion) 257–258, 16 figs. Deals with carburizing process when using solid compounds; production of carburizing gases from cement and their reaction on steel; study is made of mechanism through which carbon is conveyed from surface inward; photomicrographs and curves.

CENTRAL STATIONS

Australia. Electrical Equipment of the Yallourn Power Station. Elec. Engr. of Australia & New Zealand, vol. 2, no. 10, Jan. 15, 1926, pp. 383–388, 6 figs. Has installed capacity of 62,500 kw. in 5 generating units; there are 12 John Thompson boilers of 70,000-lb-per hr. evaporative capacity each, burning brown coal exclusively; turbines are of impulse (Rateau) type; main generators are of 12,500-kw. capacity each and generate at 11,000 volts, 3 phase, 50 cycles.

Cleveland, Ohio. Construction Work Progresses at Avon Station. Power Plant Eng., vol. 30, no. 6, Mar. 15, 1926, pp. 380–381, 4 figs. New plant of Cleveland Electric Illuminating Co., designed for 300,000-kw. ultimate capacity, to have pulverized fuel-fired boilers.

Columbia Park, Ohio. The New Columbia Power Station. Elec. Light & Power, vol. 4, no. 1, Jan. 1926, pp. 23–24 and 125–126, 4 figs. Located at confluence of Ohio and Big Miami Rivers, at Columbia Park, Ohio; two turbines, each of 45,000 kw., will generate 120,000 hp., and serve electric energy to greater part of Southwest Ohio and Northern Kentucky.

Des Moines, Iowa. New Des Moines Power Station. Power, vol. 63, no. 16, Apr. 20, 1926, pp. 590–595, 8 figs. Initial two-unit installation designed for ultimate capacity of 166,200 kva.; large underwater storage for Iowa coal; boilers equipped with forced-draft chain grates, economizers, air heaters and evaporators; stage bleeding from main units and motor-driven auxiliaries starting at full voltage.

England. Extensions at St. Helens. Elec. Times, vol. 69, no. 1798, Apr. 1, 1926, pp. 417–418, 3 figs. Extensions comprise 6500-kw. Brush-Ljungström turbo-alternator and condensing plant, British Thomson-Houston switchgear, one 1000-kw. Bruce Peebles motor-converter, one 40-ton electrically driven Royce crane, four 35,000-lb. Babcock & Wilcox water-tube boilers, etc.; enlargement of engine-house building and erection of new structural steel boiler house. See also description in Elecn., vol. 96, no. 2498, Apr. 2, 1926, pp. 382 and 386.

Germany. The Goldenberg Central Station (Das Goldenberg-Werk und das Versorgungsgebiet des RWE), W. Kraska. Elektrotechnische Zeit., vol. 47, nos. 3 and 4, Jan. 21 and 28, 1926, pp. 65–70 and 104–108, 14 figs. Details of 400,000-kw. station, which is largest in Europe; it is near Cologne at mouth of soft-coal mine and in close proximity to Rhine River; total of 600 mi. of 110-kv. transmission lines, to which are connected 14 substations, carries energy to large number and wide variety of power consumers; 68 boilers are installed in 4 large boiler houses; each boiler can furnish 30 tons of steam per hr. at 15½-atmos. pressure; there are 6 turbo sets of 15,000 kw. and 4 of 55,000 kw. each; it is planned to connect plant with Munich in near future over 220-kv. line.

Middletown, Pa. Design and Test of Susquehanna Station, E. M. Gilbert. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 362–368, 11 figs. Details of preliminary studies made in design of Metropolitan Power Co.'s 30,000-kw. pulverized-coal-burning power plant at Middletown, Pa., together with data on performance obtained in tests.

Winnipeg, Manitoba. Winnipeg's Steam Plant, G. Mossman. Elec. News, vol. 35, no. 7, Apr. 1, 1926, pp. 29–37, 9 figs. Used at same time as emergency standby and for heating purposes; much of equipment is of English manufacture.

CHROMIUM STEEL

Ascoloy. Characteristics of Ascoloy. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, p. 609. Characteristics of ductile and malleable chromium-steel alloy made in electric furnace. Reference-book sheet.

Electric Melting. Melt High Chromium Alloys in Acid Furnace, R. S. Kerns. Iron Trade Rev., vol. 78, no. 12, Mar. 25, 1926, pp. 812–814; also Foundry, vol. 54, no. 6, Mar. 15, 1926, pp. 229–231. Gives uses of high-chromium alloy steel and relates experience in melting alloy in acid electric furnace; although high losses of chromium were expected, reverse was true.

COAL

Liquefaction. The Liquefaction of Coal (Die Verflüssigung der Kohle), F. Berguis. Glückauf, vol. 61, nos. 42 and 43, Oct. 17 and 24, 1925, pp. 1317–1326 and 1353–1358, 16 figs.; also in Montanistische Rundschau, vol. 18, no. 6, Mar. 16, 1926, pp. 184–199, 16 figs. Notes on physical and chemical process; liquefaction through direct hydration; account of author's tests and their results; continuous tests and arrangement of equipment; principle, advantages and success of Bergius process.

COAL HANDLING

Power Plants. Methods of Handling Fuel and Waste in the Power House, G. F. Zimmer. Indus. Mgmt. (Lond.) (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 96–102, 6 figs. Deals with propositions arising from varying topographical conditions of power-house site, giving practical solutions in each case for dealing with handling of coal.

Types of Apparatus. Conveying Plants for Coal (Förderanlagen für Kohle), K. Wagner. Elektro-Journal, vol. 5, no. 24, Dec. 25, 1925, pp. 435–442, 18 figs. Design and operation of various types, including bucket conveyors; automatic scales; belt and scraping conveyors; ship-unloading plant; transportable belts for conveying and piling; suspended rail lines; pneumatic suction and pneumatic pressure plants, etc.

COLD STORAGE

Air Cooling in Rooms. Air Cooling in Cold Storage Rooms. Sulzer Tech. Rev., no. 1, 1926, pp. 9–15, 11 figs. Describes various systems of air coolers, advantages and disadvantages, with particular attention to various types constructed by Sulzer Bros.

Fish Handling and Transport. The Handling and Transport of Fish, J. M. Tabor. Brit. Cold Storage & Ice Assn.—Proc., vol. 22, no. 1, 1925–26, pp. 11–18 and (discussion) 19–29. Problems and suggestions.

COMPRESSED AIR

Properties and Uses. Compressed Air and Air Compressors, C. H. Sonntag. Pit & Quarry, vol. 11, nos. 10 and 11, Feb. 15 and Mar. 1, 1926, pp. 59–63 and 95–100. Properties of compressed air; gas laws; specific heat at constant pressure; adiabatic and isothermal compression; two-stage compression; displacement; volumetric efficiency and effect of altitude of compressors; transmission of compressed air; measurement of air flow; loss through leaks.

CONDENSERS, STEAM

Metropolitan-Vickers. Modern Condensing Plant. Eng. & Boiler House Rev., vol. 39, no. 9, Mar. 1926, pp. 453–456, 4 figs. Deals with range of design produced by Metropolitan-Vickers Elec. Co.

Tubes. Condensing Equipment. Jl. Electricity, vol. 56, no. 7, Apr. 1, 1926, pp. 259–261, 2 figs. Serial report of Prime Movers Committee, P. C. E. A.; efforts of committee have been confined to trying to find causes and remedies for tube failures in condensers such as are used for condensing steam from prime movers in power plants.

CORE OVENS

Design. Oven Design Shows Advance, C. A. Barnett. Foundry, vol. 54, no. 6, Mar. 15, 1926, pp. 240–241, 4 figs. Deals with Shelf, drawer-type, portable rack-type, car-type and conveyor ovens.

CORROSION

Oxygen Removal from Water. Removing Dissolved Oxygen From Water, W. J. Risley, Jr. Chem. & Met. Eng., vol. 33, no. 3, Mar. 1926, pp. 63–164, 3 figs. Equipment used for preventing corrosion occurring due to heated water containing this gas when in contact with iron or steel.

Sodium Silicate as Preventive. Sodium Silicate as a Corrosion Preventive, R. P. Russell. Mass. Inst. Technology—Publications, vol. 61, no. 69, Feb. 1926, 4 pp., 4 figs. Deals with use of sodium silicate (water glass) as means of decreasing corrosion in water heaters and pipe lines.

CRANES

Bridge, Brakes for. Automatic Protective Brake for Traveling Loading Bridges and Cranes (Selbsttätige Windschutzbremse für fahrbare Verladebrücken und Krane), Uebbing. Fördertechnik u. Frachtverkehr, vol. 19, no. 5, Mar. 5, 1926, pp. 61–62, 2 figs. Details of design and operation of automatic brake Esslingen Maschinenfabrik which acts in case loading bridge is put in motion unintentionally (by force majeur, etc.).

Building. Building Cranes (Ueber Baukrane), W. Lattmann. Schweizerische Bauzetung, vol. 87, no.

1, Jan. 2, 1926, pp. 8–10, 5 figs. Development of building cranes used in construction; lattice-girder tower cranes, present type consisting of fixed and movable lattice girder; electric drive, brakes, controls, etc.

Floating. A 65-Ton Floating Crane (65 t-Schwimmkran), Momber. Schiffbau, vol. 27, no. 4, Feb. 24, 1926, pp. 91–94, 5 figs. Built up from material cut away from dismantled naval vessels in Kubatz yard at Wilhelmshaven, Germany; hull was made from an old pontoon which was horizontally cut in two; lower portion was made to serve as forward pontoon of crane, and upper, reversed, after pontoon; two side pontoons were connected to main structures; remaining details were supplied from English and German war and merchant vessels; machinery was obtained in similar manner.

Hydraulic Cargo. Hydraulic Cargo Cranes on the Motor Liner Asturias. Engineer, vol. 141, no. 3665, Mar. 26, 1926, p. 364, 3 figs. Equipment comprises two sets of motor-driven hydraulic pumps, with Ward-Leonard electrically controlled motor-generator, air-lined hydraulic accumulator, and 12 hydraulic cranes which serve 6 cargo hatches.

Jib. New Jib Cranes for Harbor Work (Neue Einziehkrane für den Seehafenumschlag), C. Overbeck. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 3, Jan. 16, 1926, pp. 73–77, 13 figs. Advantages of jib or luffing cranes for sea harbors; different types of jib cranes erected by Bremen Harbor Administration for gaining experience as to most desirable type.

Power. Power Cranes (Krane mit eigener Kraftquelle), F. Woeste. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 9, Feb. 27, 1926, pp. 291–296, 17 figs. Steam-driven cranes; cranes with internal-combustion engine; storage-battery and automobile cranes.

Shipbuilding. The Crane Equipment of Shipbuilding Berths, E. Smith. Engineering, vol. 121, no. 3145, Apr. 9, 1926, pp. 480–482, 7 figs. Considers from point of view of mechanical efficiency, different types of cranes. Paper read before Instn. Nav. Architects.

Slewing Motion. The Forces Involved in the Slewing Motion of Power Cranes, E. G. Fiegehen. Engineering, vol. 121, no. 3146, Apr. 16, 1926, pp. 483–484, 2 figs. Chief forces and resistances that have to be overcome in operating slewing motion are: (1) friction—of rollers, pins, gearing, bearings, etc.; (2) unbalanced wind forces; (3) inertia forces in accelerating moving parts; (4) gravity—in cases where crane is out of level; three typical cranes are taken to illustrate method of calculation.

Traveling. Traveler Erects Heavy Trusses for Theater Roof. Eng. News-Rec., vol. 96, no. 11, Mar. 18, 1926, pp. 454–455, 5 figs. Steel traveler of remarkable size used in erecting columns and trusses for auditorium of Paramount Theater Building in New York; trusses weighing up to 150 tons lifted 130 ft. and set on columns 120 ft. high by traveler carrying two 75-ton derricks.

CRANKCASES

Machining. Willys-Knight Production Methods, F. H. Colvin. Am. Mach., vol. 64, no. 12, Mar. 25, 1926, pp. 461–463, 8 figs. Methods and equipment used in machining crankcases.

CRANKSHAFTS

Torsional Vibration. Torsional Vibrations in Automobile Engines (Drehschwingungen des Automobilmotors), J. Plünzke. Motorwagen, vol. 29, no. 6, Feb. 27, 1926, pp. 115–128, 27 figs. Complete treatment of torsional vibrations of crankshafts, drawing upon large amount of research and literature; applies theories and methods developed by other investigators to three cases of specific interest to automotive engineers, crankshafts of 4-, 6- and 8-cylinder engines, and shows by actual examples how vibration period of such shafts can be calculated.

CUPOLAS

Coke Beds. Judging the Coke Bed in the Cupola, R. A. Knight. Foundry, vol. 54, no. 5, Mar. 1, 1926, pp. 177–179, 3 figs. Discusses difficulties encountered by foundryman in judging coke bed when melting in cupola; describes easy correction measure and quick run.

Melting Losses. Losses in Melting, from Cupola to Finished Casting, R. Coulthurst. Mech. World, vol. 79, no. 2044, Mar. 5, 1926, p. 184. Causes determining losses are: (1) insufficient fuel; (2) too much air admitted, thus increasing amount of iron that is oxidized; (3) insufficient supply of limestone to flux away silica.

Operation. The Cupola Furnace, J. E. Hurst. Foundry Trade Jl., vol. 33, nos. 498 and 499. Mar. 4 and Mar. 11, 1926, pp. 170–172 and 199–200, 3 figs. Notes on combustion of coke; thermal balance sheet; cupola melting zone; escaping-gas analysis; improved cupolas. Mar. 11: Factors in cupola design; tuyere area; number and shape of tuyeres.

CUTTING METALS

Cutting Action and Tools. Cutting, W. R. Ward. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 482–486, 3 figs. In cutting of materials force must be applied either to cutting tool or to material being cut in order that tensile strength of material may be exceeded as edge of tool advances and ruptures fibers; angle at which force is applied is significant; thin wedge-shaped tool reduces wedge resistance and allows more force to be applied on cutting edge; for hard substances more blunt wedge-shaped tool is necessary than for soft fibrous materials.

Cutting Tests of Tools. Cutting Tests of Tool Steels, J. Strauss. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 571–584, and 648, 9 figs. Deals with cutting ability of tools and tool steels and cutting resistance of metals; sets forth 3 classes of tools for cutting metals and describes various experimental tests made in determining failure of tools; general precautions necessary to be taken in various methods of testing. Bibliography.

D

DIE CASTING

Aluminum Alloys. The Die-Casting of Aluminum Alloys. Machy. (Lond.), vol. 27, no. 703, Mar. 18, 1926, pp. 812–814. Discussion of paper by G. Mortimer presented before Inst. of Metals. Crystallization shrinkage; nomenclature.

DIESEL ENGINES

Airless-Injection. West Coast System of Airless Injection. Motorship (N. Y.), vol. 11, no. 4, Apr. 1926, pp. 289–292, 21 figs. Design, construction and operation of Pacific Coast types of airless-injection Diesel engines.

Compound. Compound Diesel Engines (Die Verbunddieselmaschine), Praktischer Maschinen-Konstrukteur, vol. 59, no. 7–8, Feb. 20, 1926, pp. 69–70, 1 fig. Engine with two high-pressure four-stroke cylinders and between them a low-pressure two-stroke cylinder used for driving a dynamo making 400 r.p.m. at output of 180 kw.; efficiency, 90 per cent.

Compressorless. Improvement in Diesel Engine Design (Neue Wege im Dieselmaschinenbau), Parey. Dinglers polytechnisches Jl., vol. 341, no 3, Feb. 1926, pp. 26–28. Discusses injection of fuel in compressorless Diesel engines by ante-chamber; eddy and pressure method and their characteristics.

Crankless. Crankless Diesel Engine. Times Trade & Eng. Supp., vol. 17, no. 396, Feb. 6, 1926, p. 514, 2 figs. Novel form of crankless Diesel engine known as Michell, of German design; power transmission is effected by means of piston rods on foremost end of which there are crossheads bearing shafts with 2 groups of rollers; scavenging is effected through 2 lower cylinders by ports governed by piston rings.

Municipal Power Plants. A Study of Diesel Engines for Municipal Power-Plants, A. L. Mullergren. Am. City, vol. 34, no. 3, Mar. 1926, pp. 240–243, 2 figs. Economics of Diesel vs. steam plant selection of type of plant; adaptation of different types; direct-connected pumps.

Shipping Board. America's Largest Four-Stroke-Cycle Diesel Ends Tests. Power, vol. 63, no. 17, Apr. 27, 1926, pp. 640–641, 3 figs. Result of test on first 2700-hp. Diesels built by McIntosh & Seymour Corp. for Shipping Board.

Small Power Plants. Diesel Engines Raise Small Plant Efficiency, R. C. Demary. Power Plant Eng., vol. 30, no. 6, Mar. 15, 1926, pp. 369–370. Comparison of costs taken from records of steam plant for ten months with corresponding period after Diesel engines were installed, showing savings effected by Diesel-engine installation.

Speed Control. Novel Speed Control for Diesel Engines, E. J. Kates. Power, vol. 63, no. 16, Apr. 20, 1926, pp. 596–598, 5 figs. N. Y. Central Railroad has placed water-pressure regulated speed control on Diesel engines driving pumps in one of its water stations, which solved difficult problem of wide-speed regulation of such oil-engine-driven units.

Temperature Variation. Temperature Variation and Heat Stresses in Diesel Engines, R. Sulzer. Engineering, vol. 121, no. 3144, Apr. 2, 1926, pp. 447–450, 21 figs. Account and results of experimental work; measurement of temperature in walls of two-cycle marine engine. Paper read before Instn. Nav. Architects. See also Engineer, vol. 141, nos. 3666 and 3667, Apr. 2 and 9, 1926, pp. 391–392 and 420–421, 21 figs.

DISKS

Rotating Explosions of. Excess Speed and Excess Pressure (Ueberschleudern, Ueberpressen), F. László. Maschinenbau, vol. 5, no 5, Mar. 4, 1926, pp. 210–213, 5 figs. Discusses danger of destruction or explosion of rotating bodies due to excess load or speed; calculates mean tangential stresses of rotating disks in range of permanent deformation, critical speed, etc.; turbine runners loosened by speed; effect of excess pressure in pipes, containers, etc

DRILLING MACHINES

Automatic. Automatic Drilling Machine. Brit. Machine Tool Eng., vol. 3, no. 37, Jan.-Feb., 1926, pp. 361–362, 2 figs. Built by J. Archdale & Co., Birmingham, Eng., for drilling small holes in tubes of special form.

Six-Spindle. Six Spindle Drilling Machine. Brit. Machine Tool Eng., vol. 3, no. 37, Jan.-Feb., 1926, pp. 363–364, 2 figs. Heavy-duty machine, built by Wm. Asquith, Ltd., for drilling holes in special types of gas burners.

DROP FORGING

Non-Ferrous Alloys. The Drop Forging of Non-Ferrous Alloys. Metal Industry (Lond.), vol. 28, nos. 7 and 9, Feb. 12 and 26, 1926, pp. 149–152 and 197–199, 1 fig. Feb. 12: Practical problems in drop-forging of aluminum alloys. Feb. 26: Practical problems in making of drop-forgings from copper and chief hot-working brasses.

DYNAMOMETERS

Electric-Tool Testing. Electric Dynamometer for Testing Electric Tools (Ueber die Konstruktion von Bremsvorrichtungen zur Prüfung elektrischer Handwerkzeugmaschinen), J. Dalchau. Elektrotechnische Zeit., vol. 47, no. 2, Jan. 14, 1926, pp. 36–38, 4 figs. Small dynamometer built on eddy-current brake system, which is particularly suited to perform correct routine testing of electric tools, such as hand drills, small drill presses, saws, etc.; tested machine is connected over ball joint to solid iron rotor which revolves within 4-polar d.c. magnetic field; both rotor and field are held in independent ball bearings; design data for dynamometer of 300 watts' capacity.

E

EDUCATION, ENGINEERING

Europe. The Engineering Scene, W. E. Wickenden. Eng. Education—Jl., vol. 16, no. 6, Feb. 1926, pp. 433–449. Critical glance at technical education in Europe and how we may profit by it.

Mechanical-Laboratory Courses. The Mechanical Laboratory Courses in the Sibley School of Mechanical Engineering, H. Diederichs. Sibley Jl., vol. 40, no. 2, Feb. 1926, pp. 29–30. Historical review of development being partly outlined of work done at present time and of its aims.

United States. The Study of Engineering and Economics in the United States (Das Studium der Technik und Wirtschaft in den Vereinigten Staaten von Amerika), H. Aumund. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 4 and 7, Jan. 23 and Feb. 13, 1926, pp. 109–115 and 229–237. Principles and aims of American university education; economical and technical training; coöperation between university and industry; educational possibilities other than standard university courses; comparison with German methods and conditions, and lessons to be learned.

ELECTRIC DRIVE

Factories. Electricity for the Factory, E. Ingham. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 73–78, 3 figs. Methods employed in production, transmission and utilization of electrical power in small factory or works.

Sectional. The Development of the Sectional Paper Machine Drive, H. W. Rodgers. Am. Inst. Elec. Engrs.—Jl., vol. 45, no. 4, Apr. 1926, pp. 323–329, 9 figs. History and development of several types of sectional drive and relative merits of each particular type; sets forth advantages of sectional drive and shows that its field of applications should increase with fuller understanding of its advantages as to increased production, improved product and lower operating cost.

Unit-Drive System. Advantages of Unit-Drive System Shown in Reorganized Factory. Jl. Electricity, vol. 56, no. 5, Mar. 1, 1926, pp. 179–182, 9 figs. Details of installation in Oakland factory of Fageol Motors Co.

ELECTRIC FURNACES

Annealing. An Electric Annealing Furnace. Elec. News, vol. 35, no. 4, Feb. 15, 1926, pp. 41–43, 3 figs. Furnace installed in Davenport Works of Can. Gen. Elec. Co. is of tunnel or box type with steel framework and movable ends or doors.

Electric Annealing Furnaces. Metallurgist (Supp. to Engineer, vol. 141, no. 3661), Feb. 26, 1926, pp. 19–20. Review of types described in recent issues of Forging—Stamping—Heat Treating, Stahl u. Eisen, and Zeit. des Vereines deutscher Ingenieure; advantages of electric furnace for commercial annealing.

Arc. Large Arc Furnace (Le four de 100,000 amperes de Saint-julien de Maurienne) P. Bergeon. Société Française des Electriciens—Bul., vol. 6, no. 53, Jan. 1926, pp. 75–80, 2 figs. Unusually large and uniquely designed furnace has been in operation since 1924 in Saint Julien, France, producing alloy steel; arc resistance furnace is built with octagonal cross-section and represents 8 furnaces combined into one, having 8 movable upper electrodes and one common bottom electrode; 4 transformers installed under furnace each feed 2 of 8 sections; total current varies between 100,000 and 120,000 amperes at average of 50 volts; current consumption of 3250 kw-hr. per metric ton of alloy steel is reached in average run.

Heating Elements. Rating of Heating Elements for Electric Furnaces, A. D. Keene and G. E. Luke. Am. Inst. Elec. Engrs.—Jl., vol., 45, no. 3, Mar. 1926, pp. 222–226, 6 figs. Study of practical considerations involved in assigning kilowatt ratings to radiant heating elements in furnace chambers; constants for radiation and absorption are given; consideration of shape and spacing of elements with respect to shielding due to adjacent elements; method of determining equivalent unshielded element is worked out to provide basis for comparing dissimilar shapes of heaters.

ELECTRIC LOCOMOTIVES

Classification. Electric Locomotive Classification, D. C. Hershberger. Ry. Elec. Engr., vol. 17, no. 3, Mar. 1926, pp. 81–82, 1 fig. New system proposed which is simple and does not have limitations of Whyte System.

Paris-Orlean Railway. A New European Electric Locomotive. Elec. World, vol. 87, no. 11, Mar. 13, 1926, p. 550. Brown-Boveri Co. of Baden, Switzerland, has recently completed first of two powerful electric locomotives for Paris-Orleans Railway Co. for use on electrified section of line between Paris and Brive, distance of 330 mi.

Single-Phase. New Single-Phase Express Locomotives in Switzerland. Ry. Engr., vol. 47, no. 555, Apr. 1926, pp. 131–135, 7 figs. 4-6-2 electric locomotives built by Maschinenfabrik Oerlikon and put into service on Swiss Federal Railways.

ELECTRIC WELDING

Butt. Notes on Electric Welding (Ein Beitrag zur elektrischen Schweissung), F. Knoops. Zeit. des Oberschlesischen Berg- u. Hüttenmännischen Vereins

zu Katowice, vol. 65, no. 2, Feb. 1926, pp. 79–85. Details of experiments in butt-welding by compression and by fusion method, or complete contact and intermittent contact method, showing that second method produces considerably better welds; annealing improves welds by first method but not those by second method.

Oil Tanks. Welding as a Means of Fabricating Tanks, Vessels and Pipes, W. Schenstrom. Am. Welding Soc.—Jl., vol. 5, no. 2, Feb. 1926, pp. 11–15. Electrically welded construction, welding on large tanks, vacuum tanks and pipe.

Processes. Electric Welding (La soudure électrique), J. Maurice. Annales de l'Energie, vol. 9, no. 19, Jan. 25, 1926, pp. 3–7. Discusses pressure welding; autogenous and arc welding; resistance or Thomson process, carbon-electrode or Bernados process; preparation of welds; uses of electric welding.

Structural Work. Electric Welding in the Design and Fabrication of Plant and Structures, J. N. Reeson. Engineering, vol. 121, no. 3145, Apr. 9, 1926, pp. 473–474. Influence of electric welding in design of structures; suggests that its employment without special consideration of design is likely to prejudice its application. (Abstract.) Paper read before Instn. Civ. Engrs.

ELECTRIC WELDING, ARC

Crane Runways. Crane Runway Built By Welding. Iron Age, vol. 117, no. 16, Apr. 22, 1926, pp. 1132–1133, 6 figs. Electric arc employed in fabrication of 14 girders and 16 "A" frames which support them; joints given severe tests.

Welded Construction for Runways. Welding Engr., vol. 11, no. 2, Feb. 1926, pp. 28–30, 10 figs. Crane runway fabricated from structural steel, in which arc welding replaced all rivets.

Hydrogen. Arc Welding in Hydrogen and Other Cases, P. Alexander. Gen. Elec. Rev., vol. 29, no. 3, Mar. 1926, pp. 169–174, 8 figs. Author shows that usefulness of hydrogen in arc welding is not limited entirely to its atomic properties; results obtained through use of this gas mainly as shield around arc; shows that some other gases also have serviceable properties in this respect.

Atomic Hydrogen Arc Welding, R. A. Weimnan & I. Langmuir. Gen. Elec. Rev., vol. 29, no. 3, Mar. 1926, pp. 160–168, 21 figs. Describes apparatus and distinctive character of results obtained.

The Hyde Hydrogen Process of Welding (Nouveau procédé de soudre). Chimie & Industrie, vol. 15, no. 2, Feb. 1926, p. 229. If certain metals, in particular, copper and copper alloys, nickel, etc., are slowly brought to melting point in atmosphere of hydrogen there is observed lowering of melting temperature and at exact instant of melting an extremely high instantaneous fluidity, copper flowing like oil on water; it is this property which has been utilized in Hyde welding process; advantage of process is that finished pieces have extremely clean appearance and as a rule do not have to be polished up; process is at present applied mainly in connection with electric-resistance welding machines.

Practice. Metallic Arc Welding, P. L. Roberts. Mech. World, vols. 78 and 79, nos. 2025, 2027, 2032, 2037, 2042 and 2047, Oct. 23, Nov. 6 and Dec. 11, 1925, pp. 325–326, 364–366 and 465–466, and Jan. 15, Feb. 19 and Mar. 26, 1926, pp. 46–47, 148–150 and 242–243, 24 figs. Oct. 23: Principles of metallic arc welding. Nov. 6: Process. Dec. 11: Welding plant; reverse-compound-wound generators. Jan. 15, 1926: Welding of cast iron. Feb. 19: Applications to manufacture. Mar. 26: Application to repairs.

ELECTRIC WELDING, RESISTANCE

Seam. Resistance Seam Welding, W. H. Gibb. Welding Engr., vol. 11, no. 3, Mar. 1926, pp. 27–29, 3 figs. Progress made in construction of machines promises to improve many products now assembled by riveting method.

ELEVATORS

Locating Faults. Locating Faults in Electric Elevators—Alternating-Current Controllers, C. A. Armstrong. Power, vol. 63, no. 13, Mar. 30, 1926, pp. 483–487, 9 figs. Different types of a.c. elevator-motor controllers, and how to locate troubles in such equipment.

EMPLOYEES

Physical Examinations. Physical Examinations in Industrial Plants, E. W. Locher. Safety Eng., vol. 51, no. 3, Mar. 1926, pp. 170–177. Points out importance of such examinations, their effect upon employer and employee.

EMPLOYEES, TRAINING OF

Teaching Economics. Teaching Economics to Industrial Employees, J. R. Barbor. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 224–225. Points out advantages of study of economics for industrial employees.

ENAMELING

Research. Researches in Enameling and Glazing. Chem. & Met. Eng., vol. 33, no. 3, Mar. 1926, pp. 167–168, 3 figs. Studies at Bureau of Standards include abrasive hardness test for glazes warpage of sheet metal and development of wet process for cast iron.

ENGINEERING

Ethics. Ethics and Engineering, C. F. Taeusch. Prof. Engr., vol. 10, no. 3, Mar. 1926, pp. 12–13 and 29. Presentation and review of leadership and accomplishments of Am. Assn. of Engrs. Practice Committee in field of professional ethics.

Science and. Science and Engineering, W. F. Durand. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 337–340. Visualization of material elements of civilization as complex products of manifold studies, fundamental and applied, that interlock and trace back to broad, basic concepts through which attempt is made to interpret phenomena of nature.

United States. Impressions Gained from a Visit to the United States (Eindrücke von einer Studienreise durch die Vereinigten Staaten von Amerika), E. Probst. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 6, 9, 11 and 13, Feb. 6, Feb. 27, Mar. 13 and 27, 1926, pp. 181–186, 297–301, 361–364 and 445–448, 10 figs. Relations between engineering and industry; merits and demerits of American education and training, and research; coöperation between engineers and between engineer and architect; influence of engineer on new American architecture; standardization and mechanization and their influence on professional development; lessons to be learned in Germany.

ENGINEERS

Compensation. Compensation of Engineers, C. S. Shaughnessy. Prof. Engr., vol. 10, no. 2, Feb. 1926, pp. 6–10, 2 figs. Significant movements for financial improvement; factors entering into compensation; address delivered before Philadelphia chapter of Am. Assn. Engrs.

Salesmanship, Value to. Should the Engineer Be a Trained Salesman? J. B. Mannion. Prof. Engr., vol. 10, no. 3, Mar. 1926, pp. 5–7 and 28, 2 figs. Shows briefly how study of salesmanship will save time, effort and money in professional engineer; increase opportunities and earnings; enable him to be a leader and increase power of his personality; show him how to be tactful and resourceful; and speed his progress toward success.

ESCALATORS

Design and Application. Mechanical Stairs, Escalators [Die mechanische bewegte Treppe (Escalator, Fahr- oder Rolltreppe)], Tränker. Zentralblatt der Bauverwaltung, vol. 46, no. 8, Feb. 24, 1926, pp. 91–94, 7 figs. Design and operation; application in subways, factories, department stores, theaters, etc.; different types of escalators.

F

FANS

Casings and Inlets. Experiments on Fan-Casings and Fan-Inlets, H. Briggs and J. N. Williamson. Instn. Min. Engrs.—Trans., vol. 70, Jan. 1926, pp. 241–258, 16 figs. Experiments carried out in Heriot-Watt College to determine (1) velocity of flow in air space between fan runner and casing; (2) effect of varying clearance between fan runner and "beak" or commencement of volute; (3) improvement to be effected by substituting casing of profile following definite mathematical relationship; (4) effect of altering width of volute whose curve has definite relationship; (5) changes brought about by using fan inlets of various forms.

FLOW METERS

Self-Recording. A New Type of Flowmeter, J. H. Powell. Sci. Instruments—Jl., vol. 3, no. 5, Feb. 1926, pp. 144–148, 4 figs. Form of flowmeter in which loosely fitting piston of neutral buoyancy is impelled along glass tube by flow of liquid, against spring control in which restoring force is proportional to square of displacement so as to obtain approximately even velocity scale.

FLOW OF LIQUIDS

Discharge Through Orifices. An Investigation of the Coefficient of Discharge of Liquids Through Small Round Orifices, W. F. Joachim. Nat. Advisory Committee for Aeronautics—Report, no. 224, 1926, 10 pp., 8 figs. Results of investigation; it is concluded that within range of these tests and for hydraulic pressures above 1000 lb. per sq. in., coefficient does not change materially with pressure or temperature; it depends considerably upon liquid, decreases with increase in orifice size, and increases in case of discharge into compressed air.

FLOW OF WATER

Measurement. Venturi Meters for Hydroelectric Power Stations. Engineering, vol. 121, no. 3147, Apr. 23, 1926, pp. 545–546. Details of venturi meter for measurement of flow in both directions, developed by Siemens & Halske, Berlin; it is claimed that 85 to 90 per cent of heat lost is recovered by suitable construction of tubes; illustrates large tubes built of reinforced concrete; in a power plant in Black Forest, meter is employed to record both flow of water to turbines and flow which takes place in opposite direction through same meter when hydraulic accumulator of plant is being charged.

FLYING BOATS

Ground Operation. Notes on the Ground Operation of Flying Boats, R. J. Mitchell. Flight (Aircraft Engr.), vol. 18, no. 12, Mar. 25, 1926, pp. 178h–178j, 2 figs. Methods employed in launching, bringing ashore and handling flying boats on ground.

FOREMEN

Industrial Americanization Work. Industrial Americanization and the Foremen, F. H. Rindge. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 593–594. Key position of foreman in American industry; how he can help Americanization work and incidentally increase production and promote safety.

Responsibilities. The Foreman's Responsibilities, F. J. Borer. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 219–220. Stopping of leaks of all kinds; constructive suggestions; attitude toward employees; public relations.

FORGING

Machines for. Modern Forging Machines (Neuere Schmiedemaschinen), A. Georg. Maschinenbau, vol. 5, no. 3, Feb. 4, 1926, pp. 114–116, 4 figs. Discusses field of application of horizontal forging machines in production of quantity goods for automobile, ball bearing and similar industries; working of "two-point" system replacing older "three-point" system.

FOUNDRIES

Air Furnaces. Air Furnace Has Underfeed Stoker, B. Finney. Iron Age, vol. 117, no. 16, Apr. 22, 1926, pp. 1119–1123, 8 figs. Use of underfeed stoker in melting furnace in foundry of Berryhill Malleable Iron Co., Evansville, Ind.; design of annealing ovens, temperature regulating equipment and annealing-cycle chart, also notable features.

American Practice. Foundry Practice in America (Amerikas Giessereiwesen), U. Lohse. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 11, Mar. 13, 1926, pp. 357–360, 10 figs. Observations based on author's visit in America for purpose of studying American foundry equipment and practice; systematic coöperation between machine-tool builder and foundryman; mechanical equipment for materials handling, sand preparation, making of molds, molding machines, coremaking, cleaning, melting, etc.

Conveyor Systems. Conveyor Systems, F. G. Steinebach. Foundry, vol. 54, no. 7, Apr. 1, 1926, pp. 256–261, 8 figs. Systems employed by Warren Foundry Co., Warren, Ohio, to transport molds and finished castings, to handle jackets, weights, bottom boards and sand, etc.

Conveyors Nearly Triple Output, F. L. Prentiss. Iron Age, vol. 117, no. 14, Apr. 8, 1926, pp. 977–982, 10 figs. Power-driven conveying systems are feature of improvements in continuous foundry of Saginaw Products Co., Saginaw, Mich.; make 2000 Chevrolet cylinder blocks a day.

Cost Accounting. Foundry Costing, C. Dicken. Foundry Trade Jl., vol. 33, no. 500, Mar. 18, 1926, pp. 215–218. System which can be used in either ferrous or non-ferrous foundries, but chiefly concerned with cost of production in cast-iron foundry from arrival of pattern into foundry to delivery of rough castings to stores.

Delivery and Output. Foundry Delivery and Output, W. J. Hiscox. Foundry Trade Jl., vol. 33, no. 501, Mar. 25, 1926, pp. 235–236, 2 figs. Describes simple expedient which was inaugurated by foundry with view to reconciling interests of delivery and output.

Flow of Work. Materials Handling and Flow of Work in Foundries (Förderwesen und Fliessarbeit in der Giesserei), K. H. Schmidt. Maschinenbau, vol. 5, no. 5, Mar. 4, 1926, pp. 206–209, 6 figs. Reviews development and gives German example, showing advantages of new method, also application in American radiator foundry.

Materials Handling. Handling Foundry Materials Efficiently, R. Micks. Can. Foundryman, vol. 17, no. 3, Mar. 1926, pp. 11–13, 2 figs. Utility of cranes; overhead systems of hoisting and conveying; electric and gasoline truck and truck tractor; conveying system of transportation; transportation in yard.

Lower Handling Costs of Foundry Materials, H. J. Payne. Foundry, vol. 54, no. 7, Apr. 1, 1926, pp. 262–264 and 282, 8 figs. Materials-handling practice of Kuebler Foundries, Easton, Pa., having productive capacity of 80 tons of malleable castings per day; use of electric industrial trucks.

Problems. Recurring Foundry Problems, D. Wilkinson. Foundry Trade Jl., vol. 33, no. 498, Mar. 4, 1926, pp. 165–169, 3 figs. Deals with troubles arising when actions and reactions occur which are not yet fully under control of founder; typical reactions; troubles from scum inclusions; blowhole defects; importance of magnetic oxide reaction; solidification voids; hot spots; diagnosis by isothermal lines; chills suggested as remedy.

FREIGHT HANDLING

Automatic Unloaders. Conveying Freight from Automatic Unloaders to Destination (Die Ueberführung Förderguts aus Selbstentladern an den Bestimmungsort), Walther. Fördertechnik u. Frachtverkehr, vol. 19, nos. 4 and 5, Feb. 19 and Mar. 5, 1926, pp. 38–39 and 59–61, 10 figs. Discusses introduction of large-capacity unloader cars for local and even main-line traffic, and describes methods of conveying contents of cars to ships or other destination, distinguishing systems in which cars are driven over slides for discharging, and systems in which slides are run along under train.

Exceptional Loads. Transport of Exceptional Loads, A. R. Polson. Inst. Transport—Jl., vol. 7, no. 5, Mar. 1926, pp. 259–265. Difficulties met with in transporting and delivering heavy packages; outline of services to be provided for and problems to be met by manufacturers exporting abroad.

FUELS

Heating Values. Heating Values and Composition of Fuels (Heizwerte und Zusammensetzung von Brennstoffen), Zeit. des Bayerischen Revisions-Vereins, vol. 30, nos. 2 and 3, Jan. 31 and Feb. 15, 1926, pp. 15–17 and 30–33. Tabular data of upper and lower heating value and chemical composition of coals from Ruhr, Silesia, Saxony; of lignites from Bavaria, Bohemia; briquets; cokes; peat; wood; liquid fuel.

Research. Significant Progress in Research on Fuels, A. C. Fieldner. Coal, vol. 1, no. 2, Mar. 1926, pp. 88–94. Origin and constitution of coal; research on preparation, storage and utilization of coal; research on combustion and carbonization; by-product coking; gas manufacture; low-temperature carbonization. Paper presented in Annals, Am. Academy of Political & Social Science.

Use and Treatment. The Use and Treatment of

Fuel, S. H. North. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 51–56, 6 figs. Compares respective calorific values of coal and oil, and gives examples of economies which may be effected where oil is employed for power production.

[See also COAL; OIL FUEL; PULVERIZED COAL.]

FURNACES, HEAT-TREATING

Salt Baths. Design and Operation of Furnaces for Salt Baths, S. Tour. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 553–569 and (discussion) 569–570, 12 figs. Points out need for proper furnace design and operation for salt-bath work; method of heating, distribution and radiation of heat and elimination of overheating are vital factors in this type of furnace; enumerates 20 general requirements regarding salt-bath furnaces.

FURNACES, INDUSTRIAL

Design and Operation. Industrial Furnaces. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 356–359. Heat losses, products of combustion, fuels, efficiency and its improvement, automatic control, selection of fuels, etc., as discussed at meeting of Am. Soc. Mech. Engrs.

Oil-Burning Equipment. Oil Burning Equipment for Industrial Furnaces, M. H. Mawhinney. Am. Soc. Steel Treating—Trans., vol. 9, no. 1, Jan. 1926, pp. 99–109 and (discussion) 109–110. Reviews installation and operation of oil-burning equipment, starting with storage tank and including auxiliary equipment; covers chief points of trouble for supplying fuel to furnace; correct arrangement of bricks inside furnace; troubles encountered in lighting cold furnace and correct procedure to follow in this operation; location and remedy of troubles other than purely mechanical failures.

G

GAGES

Krupp, for Fits. The Krupp Gage for Fits (Das Kruppsche Passungsfühigerät), Lehmann. Kruppsche Monatshefte, vol. 7, Feb. 1926, pp. 32–34, 5 figs. Design and application of new gage intended to afford comparison by touch of tolerances between shafts and bores, consisting of very slightly conical shaft and movable ring, which latter may be moved in accordance with scales of tolerances for fits shown on shaft; may be used for German DIN fits on any others.

[See also OPTICAL INSTRUMENTS.]

GALVANIZING

Crapo Process. Crapo Galvanizing Process. Metal Industry (Lond.), vol. 28, no. 14, Apr. 2, 1926, p. 315, 1 fig. New process developed at research laboratory of Indiana Steel & Wire Co., which solves problem of producing non-peeling, non-cracking zinc coating on iron wire.

GAS ENGINES

Power Plants. The Gas Engine, P. S. Caldwell. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 88–95, 19 figs. Its design and application in modern power house; details of most important British types; running costs and results which may be expected from carefully kept installation working either on town, producer, blast-furnace or coke-oven gas.

Steel Works. Application of the Gas Engine to the Manufacture of Iron and Steel, J. E. James and C. Cook. Iron & Coal Trades Rev., vol. 112, no. 3030, Mar. 26, 1926, p. 525. Deals with conditions applicable to economic manufacture of iron and steel, and more particularly where blast-furnace plants are part of, or adjacent to, steel works; comparison between gas engines and steam turbos; performance of turbo-generator and gas engine.

GAS PRODUCERS

Cost. A Few Points on Gas Producer Costs, J. A. Voorhies. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 240–241. Gives analysis of cost figures for two raw-gas producer plants of normal size so that relative idea as to comparative costs to other gaseous fuels may be obtained.

Steam Generators, Direct Application to. Complete Gasification of Coal for Firing Boilers, C. H. S. Tupholme. Chem. & Met. Eng., vol. 33, no. 3, Mar. 1926, pp. 160–162, 5 figs. Producers directly applied to steam generators, either with or without by-product recovery, have recently received much attention in Great Britain.

GAS TURBINES

5000-Kw. Oil and Gas Turbines: A 5000-Kw. Unit Built. Oil Engine Power, vol. 4, no. 4, Apr. 1926, pp. 217–218. Outlines basic conditions, which indicate fuel consumption of such turbines is not too high for locomotive work.

GEAR CUTTING

Cutter-Grinding Machine. "National Cleveland" Gear and Cutter-Tooth Grinder. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 613–615, 6 figs.; also description in Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 623–626, 10 figs. Machine for grinding gears and gear shaper cutters by Simmons method, developed by National Tool Co., Cleveland.

Shaper Cutters. The Design and Application of Gear-Shaper Cutters, H. Walker. Machy. (Lond.), vol. 27, no. 699, Feb. 18, 1926, pp. 671–673, 7 figs. Pressure-angle correction of cutter; application to thread cutting.

Super-Accurate Production. The Super-Accurate Production of Spur Gears on the Gear Shaper, H. Walker. Engineer, vol. 141, no. 3664, Mar. 19, 1926, pp. 316–317, 3 figs. Presents graphical method of correction, reduced to its simplest possible terms.

GEARS

Grinding. Gear Grinding, H. Darbyshire. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 108–110, 3 figs. Practical considerations that underlie production of high-grade gears; limitations of generating process; need for specialization; standardization.

GOVERNORS

Inertia. A New Inertia Governor. Engineer, vol. 141, no. 3667, Apr. 9, 1926, pp. 419–420, 1 fig. Form of governor primarily intended for controlling marine internal-combustion engine made by Ramsay, Jackson and Co.

GRINDING MACHINES

Internal. Automatic Internal Grinding Machine. Engineering, vol. 121, no. 3140, Mar. 5, 1926, pp. 317–319, 7 figs. Latest improvements in machine constructed by Heald Machine Co., Worcester, Mass.

H

HAMMERS

Forging. "Bates" Pneumatic Forging Hammer. Am. Mach., vol. 64, no. 18, May 6, 1926, p. 732, 1 fig. Hammer manufactured by Williams, White & Co., Moline, Ill., designed to deliver full power on first blow as well as full speed on light blows; it is self-contained unit and can be operated by means of direct-connected motor or by belt.

HANGARS

Germany. German Hangars (Die deutschen Luftschiffhallen), F. Stahl. Luftfahrt, vol. 29, no. 24 and vol. 30, no. 2, Dec. 20, 1925 and Jan. 20, 1926, pp. 375–377 and 21–24, 10 figs. List and date of hangars (84) built 1899–1917; description of hangars of Wittmund, Biesdorf (rotary), Liegnitz, Mannheim, etc.

Inexpensive Type. An Inexpensive Serviceable Hangar. Aviation, vol. 20, no. 11, Mar. 15, 1926, pp. 370–371, 6 figs. Simple building of corrugated galvanized iron, rough dressed lumber and garage hardware; built in Kansas for less than $600.

HARDNESS

Testing Machines. Elastic Ring for Verification of Brinell Hardness Testing Machines, S. N. Petrenko. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 420–429, 3 figs. Common methods of verification of Brinell hardness-testing machines and allowable errors in these machines; apparatus designed for accurate verification of Brinell machines; method of verification consists of measuring deflection of steel ring in machine to be verified and this deflection is compared with that obtained in deadweight Brinell machine.

HOBBING MACHINES

Pfauter. Pfauter Gear-Hobbing Machine. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 666–667, 3 figs. Automatic machine for producing spur, helical and worm gears.

HOISTS

Skip Buckets. The Tipping Phenomenon of Buckets in Skip Hoists. (Der Kippvorgang des kippenden Kübels bei der Kübelförderung), P. Walter. Fördertechnik u. Frachtverkehr, vol. 19, nos. 2 and 4, Jan. 22 and Feb. 19, 1926, pp. 17–18 and 41–43, 14 figs. Two types of skip buckets used in mines, their advantages and drawbacks; mechanism of tipping; suitable development of guides; calculation of admissible speed.

HYDRAULIC PRESSES

Electro-Hydraulic. Electro-Hydraulic Forging Press for the Mining and Metallurgical Industry (Elektrische Grossantriebe mit Leonardsteuerung in der Berg- und Hüttenindustrie), E. Riecke. Elektrotechnische Zeit., vol. 47, no. 4, Jan. 28, 1926, pp. 97–99, 5 figs. Construction and electric drive of electro-hydraulic press, operating on principle similar to that of steam-hydraulic press, for maximum pressure of 2000 tons and capacity for reducing steel ingots 2 ft. in 2 minutes; 417-kw. d.c. motor drives over 3-to-1 reduction a rack and pinion which actuates hydraulic piston every time when main forging press or shear makes its power stroke; specially adapted Ilgner motor-generator, with 7-ton flywheel, relieves electric supply line of excessive voltage fluctuations; semi-automatic control system.

Pump and Accumulator Capacity. Pump and Accumulator Capacities for Hydraulic Presses. Machy. (Lond.), vol. 27, no. 703, Mar. 18, 1926, p. 807. Method of determining capacity of pump and accumulator to serve specified number of presses to operate at predetermined speed and stroke.

HYDRAULIC TURBINES

Cavitation. The Kaplan and Propeller Turbines and the Cavitation Problem, E. Englesson. Engineering, vol. 121, no. 3146, Apr. 16, 1926, pp. 484–486, 7 figs. Review of investigations of cavitation phenomenon; factors which influence occurrence of cavitation, namely, static suction head, axial velocity of exit from runner, and length of blade in direction of flow compared to pitch of blade; describes special cavitation laboratory installed at Verkstaden Kristineham.

Developments. Hydraulic Turbines, Research and Theory (Wasserkraftmaschinen in Forschung und Theorie), B. Eck. Zeit. für Technische Physik., nos. 1 and 2, 1926, pp. 18–23 and 71–76, 22 figs. Discusses adaptation of turbines to heads; quantity of water; topographical conditions; and development of various types like Pelton, Francis and Kaplan; specific r.p.m. and coefficient of efficiency; development of high-speed turbines; theory of radial and of axial turbines.

Maintenance. Hydraulic Maintenance at Holtwood Plant, T. C. Stabley. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 341–349, 10 figs. Conditions causing deterioration of hydraulic turbines; overcoming effects of corrosion; thrust bearings; maintenance of turbines and governors; pitting of runners; safe practices during turbine repairs; governor-control system; inspections.

Testing Laboratory. Turbine Testing Plant of T. Bell & Co. at Kriens (Die Turbinen-Versuchsanlage der A.-G. der Maschinen-fabrik von Theodor Bell & Cie., Kriens), O. Walter. Schweizerische Bauzeitung, vol. 87, nos. 9, 10 and 11, Feb. 27, Mar. 6 and 13, 1926, pp. 111–116, 125–130 and 146–148, 33 figs. Layout, construction and equipment of plant consisting of reservoir of 140-cu. m. capacity; low, medium and high-pressure pumps and adjustable flumes for testing turbines of various types and for various heads; regulation and circulation of water; measuring head and quantity of water; determining efficiency, side thrust, r.p.m., etc.; tests with high-pressure plant, Bell extra-high-speed turbine, etc.

Venting. Venting Waterwheels for Efficiency, F. Nagler. Elec. World, vol. 87, no. 14, Apr. 3, 1926, pp. 699–703, 6 figs. Among advantages are improvement of speed regulation and runner and draft-tube efficiency, reduction of gate leakage and turbine vibration, provision of vacuum for power-house cleaning, etc.; limitations and precautions, how data to indicate best load apportionment are obtained; venting methods, explanation of effects.

HYDROELECTRIC DEVELOPMENTS

France. Hydraulic Developments of the Midi Railway in the Ossau Valley. Engineer, vol. 141, no. 3666, Apr. 2, 1926, pp. 376–379, 9 figs. Three power stations have been arranged for, one below the other; lowest of these stations, that at Hourat, is now in operation; middle station at Miègebat is practically completed; and upper, Artouste, station is in progress; design and equipment of these stations.

Georgia. Hydro-Electric Development in Georgia. Elec. World, vol. 87, no. 15, Apr. 10, 1926, pp. 750–756, 16 figs. Completion of projects on Tallulah and Tugalo Rivers will result in average annual output of 531,000-000 kw-hr.; storage reservoirs and power houses; operation of system.

HYDROELECTRIC PLANTS

Automatic. Automatic Hydro Plants of the Detroit Edison Co. Power Plant Eng., vol. 30, no. 6, Mar. 15, 1926, pp. 352–358, 10 figs. Six automatic and remote-controlled hydroelectric plants on Huron River in Michigan, with total capacity of 7800 kw., serve Ann Arbor and Ypsilanti district.

British Columbia. The Stave Falls Development, E. E. Carpenter. Jl. Electricity, vol. 56, no. 5, Mar. 1, 1926, pp. 172–178, 7 figs. Improvements and additions at Stave Falls hydro plant of British Columbia Elec. Ry. Co. make available to that company's system another 21,000-kva. block of power; details of intake, main and blind-slough dams; machinery and switching equipment, etc.

California. Balch Hydro Plant to Operate at 2740-ft. Head. Power Plant Eng., vol. 30, no. 7, Apr. 1, 1926, pp. 433–434, 4 figs. First unit of 500,000-hp. hydroelectric project of San Joaquin Light and Power Corp., Fresno, Cal., now under construction.

Calumet Island, Canada. The Ottawa River at Calumet Island. Elec. News, vol. 35, no. 6, Mar. 15, 1926, pp. 31–33, 4 figs. Power house planned for three 22,500-kva. units of which one is installed and operated; transmission of 72,000 volts to Hull.

Washington. Engineering Features of the Baker River Development, L. N. Robinson. Elec. World, vol. 87, no. 11, Mar. 13, 1926, pp. 547–550, 6 figs. Latest plant of Puget Sound Power & Light Co., contains two 19,500-kva. double overhung units; generators are synchronized automatically; electrical equipment installed indoors.

I

IMPACT TESTING

Notched-Bar Tests. Interpretation of Notched Bar Impact Test Results, P. Heymans. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 604–610 and (discussion) 610–614, 7 figs. Results of author's investigation made by means of photoelastic method of stress distribution around notches used in impact tests; shape and dimensions of notches were analyzed under uniform static longitudinal pull and below elastic limit.

Notes on Impact Testing and the Impact Strength of Copper, Aluminium and Certain Brasses at Different Temperatures, F. Sauerwald and H. Wieland. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 45–47, 1 fig. General consideration of phenomena of notched-bar impact test; experimental investigation of Moser's assumptions. Abstract translated from Zeit. für Metallkunde, vol. 17, Nov. and Dec. 1925. (See reference to original article in Eng. Index 1925, p. 394.)

INDICATORS

High-Speed Engines. The Gale Indicator for High-Speed Engines. Engineering, vol. 121, no. 3141, Mar. 12, 1926, p. 350, 1 fig. Describes indicator which

has advantages of being simple and comparatively inexpensive and of giving ordinary pencil diagrams on paper cards, although it can be used for indicating engines running at 5000 r.p.m., or at even higher speeds; essential feature is employment of two concentric cylindrical rotary valves between engine cylinder and indicator cylinder to put the two in communication with each other at different points of expansion curve.

Mean-Pressure. The M.I.P.-Meter, J. Geiger. Oil Engine Power, vol. 4, no. 4, Apr. 1926, pp. 223–226, 15 figs. Details of mean-pressure indicator, for purpose of directly and continuously registering mean pressure within cylinders of reciprocating engines of all kinds at any instant; with assistance of curve thus registered, satisfactory recording of total power consumption is made possible; at same time practical means are afforded for seeing how load is distributed at any moment.

INDUSTRIAL MANAGEMENT

Budgeting. Forseeing Volume of Coming Orders, J. H. Barber. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 253–256, 2 figs. Author shows how to construct barometer curve from four groups of Federal Reserve statistics that indicate change in gross profit margins.

Estimates, Preparation of. The Use of Graphs in the Preparation of Estimates, E. G. Fiegehen. Mech. World, vol. 79, no. 2042, Feb. 19, 1926, pp. 146–147. Examples of uses to which estimating graphs may be put.

Financial and Industrial Investigations. Judging Operating Results, A. Andersen. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 277–280. Analysis of operating statements in financial and industrial investigation; determination of profits; importance of depreciation and appreciation; profit-and-loss statement; consideration of gross profits and costs.

Inventory Control. The Control of Inventory Through the Scientific Determination of Lot Sizes, H. S. Owen. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 257–260, 3 figs. Perpetual-inventory stock records.

Materials-Cost Standardisation. Material Costs Can Be Standardized, F. H. Figsby. Factory, vol. 36, no. 3, Mar. 1926, pp. 431–432 and 586, 2 figs. It is found in actual practice that when raw-material costs are variable, standard costs offer special advantage because they quickly draw executive's attention to cost fluctuation that may make adjustments in selling price advisable.

Production Control. Maintaining Hourly Control of Production, G. G. Brooke. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 271–275, 7 figs. How E. G. Budd Mfg. Co., world's largest all-steel automobile body plant, regulates manufacturing operations.

Production Simplification. One-Day Production, E. Carlson. Factory, vol. 36, no. 3, Mar. 1926, pp. 433–435, 464, 466, 538, 540 and 542, 4 figs. How machine grouping, simplified layout, and conveyors have simplified production.

Project Engineers. Functions of a Project Engineer in a Technical Organization, J. F. Hardecker. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 641–642. Complete analysis made of system whereby one engineer follows through an assignment from preliminary design to finished product.

Purchasing. General Motors "Purchasing Power" Index, H. G. Weaver. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 291–292. Guide to marketing effort in different territories.

INDUSTRIAL PLANTS

Efficiency. Plant Efficiency. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 360–361. Problems affecting plant efficiency, including selections of site, plant design, site limitations affecting layout, etc., discussed at meeting of Am. Soc. Mech. Engrs.

Power-Costs Control. How Shall a Manager Control His Power Costs? W. H. Larkin, Jr. Factory, vol. 36, no. 3, Mar. 1926, pp. 444–445, 1 fig. Standard, monthly power report, as adopted by wide variety of industries, proves its case for simplicity and effectiveness; it is revolutionizing power costs in many plants.

INDUSTRIAL RELATIONS

Improving. Promoting Friendly Relations in Industry, E. M. Herr. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 621–622. Method as worked out at Westinghouse plant, East Pittsburgh, Pa.; distinction between owners and management in modern industrial undertakings; responsibilities of management of industrial enterprise.

Maintenance. Maintenance of Proper Relations Between Employer and Employee, E. M. Herr. West. Machy. World, vol. 17, no. 3, Mar. 1926, pp. 99–100 and 135. Discusses problems involved, comprising training, handling and disciplining of all employees in such manner as to keep them satisfied and to bring about most effective production relationship to industry; stresses importance of coöperation between employer and employees.

INSULATION, HEAT

High-Temperature. High Temperature Insulation, C. S. Gillette. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 1, Feb. 1926, pp. 3–16, 3 figs. Advantages of proper heat insulation if piping and machinery on shipboard.

INTERCHANGEABLE MANUFACTURE

Accuracy Control. Accuracy Control in Interchangeable Manufacture, C. O. Herb. Machy. (N. Y.), vol. 32, no. 9, May 1926, pp. 683–686, 6 figs. How White Motor Co. specifies limits on parts and gages from standardized lists and systematically inspects all gages.

INTERNAL-COMBUSTION ENGINES

Combustion. Control of Carburation in Explosion Engines by Exhaust-Gas Analysis and Carburation Curves (Contrôle de la carburation dans les moteurs à explosion par l'analyse des gaz d'échappement dans les moteurs explosion par l'analyse des gaz d'échappement et les diagrammes de carburation), B. Jousset. Chaleur et Industrie, vol. 7, no. 71, Mar. 1926, pp. 124–126, 1 fig. Shows how to determine ratio of air to fuel in engine by determining CO_2 contained in exhaust gas, considering theoretically perfect combustion, combustion with excess of air, and combustion with lack of air.

Cylinders. Thermal Stresses in Engine Cylinders, D. Laugharne-Thornton. World Power, vol. 5, no. 27, Mar. 1926, pp. 136–145, 5 figs. Examines principal factors to be considered in determination of stresses which arise in internal-combustion-engine cylinder as result of changes of temperature which such part is subject to during ordinary cycle of engine.

Instruments for. Instruments for Internal-Combustion Engines. Shipbldr., vol. 33, no. 187, Mar. 1926, pp. 150–151, 6 figs. Thermoelectric pyrometers for determining exhaust temperatures; instruments for obtaining accurate indicator diagrams.

Power Plants. The Internal Combustion Engine in the Power House, J. Richardson. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 81–84, 5 figs. Historical survey of development; chief type of engines at present in use.

Temperature Distribution and Heat Stresses. Temperature and Heat Stresses in Internal-Combustion Engines (Temperaturverlauf und Wärmespannungen in Verbrennungsmaschinen). Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 13, Mar. 27, 1926, pp. 429–436, 21 figs. Temperature distribution in cylinder walls; heat stresses when starting and during operation; temperature measurements on a Sulzer 2-stroke marine engine.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON ALLOYS

Iron-Chromium. The Nature of the Alloys of Iron and Chromium, E. C. Bain. Am. Soc. Steel Treating—Trans., vol. 9, no. 1, Jan. 1926, pp. 9–32, 18 figs. Development and preservation at room temperature of delta-iron solid solution; study covers range of alloys between pure and 30 per cent chromium; alloys containing more than 25 per cent chromium are without transformation; with this chromium content carbon in excess of 40 per cent is required to produce appreciable amount of austenite at any temperature; in alloys containing more than 10 per cent chromium, delta iron is produced in form sufficiently stable to be quenched unchanged to room temperature; carbon acts to increase solubility of chromium in gamma iron and to render it stable constituent in alloys containing more than 14 per cent chromium.

Iron-Silicon. Iron and Silicon. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 43–44, 1 fig. Review of work by Wever and Giani on investigation of iron-silicon alloys, account of which is published in Stahl u. Eisen, Jan. 14, 1926.

IRON AND STEEL

Warping. Why Metal Warps and Cracks, J. F. Keller. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 373–400 and (discussion) 400–402, 12 figs. Factors which come into play in causing iron and steel bodies to warp or crack when subjected to heat; illustrates by means of diagrams and experiments manner in which these factors cause failure of metallic bodies; photographs show effect of external strains.

IRON CASTINGS

Chilled. Making Chilled Castings in Jobbing Foundries, R. Coulthurst. Mech. World, vol. 79, no. 2047, Mar. 26, 1926, pp. 246–247. Discusses difficulties encountered by jobbing foundry, as follows: size of chill, nature of metal to be used, temperature of molten metal entering mold, chief differences in molding as against molds for ordinary castings, and depth of chill.

Methods and Processes. Comparisons in Foundry Methods and Processes, E. Longden. Foundry Trade Jl., vol. 33, no. 501, Mar. 25, 1926, pp. 227–232, 29 figs. Notes on oil-sand cores, wooden frames, molding tackle, gas-and-oil-engine pistons and liners; cupola design; solid and drop bottoms; special iron.

Notes on the Production of Castings. Foundry Trade Jl., vol. 33, no. 501, Mar. 25, 1926, p. 226. Cupola practice; sand problem; venting and cores; causes of defects. Abstract.

The Manufacture of Iron and Steel, F. T. Sisco. Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 305–322, 1 fig. Describes manufacture of iron and steel castings; method of preparing mold; various kinds of molds and their uses; iron for castings is melted in cupola using coke as fuel; various steel-making processes described insofar as they are used for production of steel for castings and their various advantages and disadvantages; preparing casting for shipment, digging out, cleaning, heat treatment and inspection.

Oxidizing. Oxidizing Cast Iron Castings, W. S. Barrows. Can. Foundryman, vol. 17, no. 3, Mar. 1926, p. 18. Term "oxidizing" includes practically all bronze finishes, employed for decorating and protecting products, which have previously received coating of copper or brass; causes of failure; oxidizing materials.

Sand Blasting. Sand Blasting and Other Aids to Fettling, F. W. Neville. Foundry Trade Jl., vol. 33, no. 497, Feb. 25, 1926, pp. 145–150, 8 figs. Discusses 3 systems of sand blasting in general use, pressure, suction and gravity feed; effect of various factors on working of plant, namely, relation between abrasion rate and flow rate, relation between flow rate and blasting efficiency, effect of air pressure on abrasion rate and blasting efficiency, life of abrasive, effect of wear on nozzles, finish obtained on cast-iron castings, etc.

L

LATHES

Crankshaft. Wickes Semi-Automatic Crankshaft Lathes. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 663–664, 4 figs. Duplex and universal types of 34-in. lathe.

Flywheel-Turning. How Nash Flywheels are Made, F. Edwards. Western Machy. World, vol. 17, no. 3, Mar. 1926, pp. 101–103 and 131, 6 figs. Details of Simplimatic, simple automatic lathe for chucking and between-centers work made by Gisholt Machine Co.; how typical installations of these lathes has increased production and reduced cost of turning flywheels.

Tests. Investigation of Small Lathes as to Design, Construction and Efficiency (Untersuchungen an kleinen Drehbänken hinsichtlich Konstruktion, Ausführung und Leistung), F. Theimer. Zeit. Oesterr. Ingenieur- u. Architekten Vereines, vol. 78, no. 3–4, Jan. 22, 1926, pp. 23–26, 4 figs. Details of tests made by Vienna Technological Museum on large number of small lathes; mathematical checking of gears, feeds and speeds; accuracy of machine parts; efficiency and quality of work.

Turret. "Steel-Head" Flat Turret Lathes. Machy. (Lond.), vol. 27, no. 701, Mar. 4, 1926, pp. 741–742, 5 figs. New designs of Jones & Lanson Machine Co.

Vertical. Modern Vertical Boring and Turning Machine for Diameters of 8300 mm. and Heights of 3200 mm. (Neuzeitliches Karussel-Drehwerk für Arbeitsstücke bis 8300 mm. Durchmesser und 3200 mm. Höhe), Weil. Praktischer Maschinen-Konstrukteur, vol. 59, no. 1–2, Jan. 9, 1926, pp. 10–12, 7 figs. Machine constructed by Schiess A. G., Düsseldorf, for machining dynamo casings, rotors, flywheels, cylinders, turbine casing, etc.; driven by 75-hp. d.c. shunt motor at 300–900 r.p.m.

LIFTING JACKS

Hydraulic. Small Hydraulic Hoisting Apparatus (Hydraulische Klein-Hebewerkzeuge). Kruppsche Monatshefte, vol. 7, Feb. 1926, pp. 26–32, 14 figs. Various types of lifting jacks built by Krupps; their application, especially in machine shops.

LIFTING MAGNETS

Design. Lifting Magnets. Machy. (Lond.), vol. 27, no. 704, Mar. 25, 1926, pp. 833–835, 5 figs. Theory underlying design; weight of coil; cooling surface; points in construction of modern lifting magnets; control equipment.

LOCOMOTIVE BOILERS

Future Possibilities. Future Possibilities of the Locomotive Boiler, L. A. Rehfuss. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 212–214. Trend towards higher pressures; objections to water-tube boiler; objections to watering type of firebox; question of high steam temperatures.

Pitting. Great Northern Reduces Pitting of Locomotive Boilers. Ry. Age, vol. 80, no. 18, Apr. 3, 1926, pp. 951–958, 7 figs. Changes in water-treating methods yield striking results; mileage doubled and tube life trebled.

Repair Parts. Standardizing and Centralizing the Fabrication of Locomotive Boiler Repair Parts. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 71–77, 19 figs. Methods of laying out and fabricating boiler sheets and developing standard repair patches.

Water-Tube. McClellon Watertube Type Locomotive Boiler. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 65–70 and 82, 13 figs. Modifications made increase boiler pressure from 180 to 250 lbs., giving greater steam economy.

The Development of Watertube Locomotive Boilers L. A. Rehfuss. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 83–86, 8 figs. Problems confronting designer of water-tube locomotive boilers and suggestions of possible trend in design.

LOCOMOTIVES

Automatic Stokers. Automatic Locomotive Firing (Ueber selbsttätige Lokomotivefeuerungen), Buhle. Wärme u. Kälte-Technik, vol. 28, no. 1, Jan. 1, 1926, pp. 2–4, 7 figs. Automatic stokers by Elvin Mechanical Stoker Co., Locomotive Stoker Co.; various types of locomotives, including Borsig and Krupp.

Central R. R. of New Jersey. Locomotive Development on the Central Railroad of New Jersey, P. T. Warner. Baldwin Locomotives, vol. 4, no. 4, Apr. 1926, pp. 8–23, 33 figs. Early motive power; review of developments.

Compound. High-Speed Compound Locomotives (Locomotive compound à grande vitesse), R. Vallantin. Revue Générale des Chemins de Fer, vol. 45, no. 2, Feb. 1926, pp. 89–100, 6 figs. Design and equipment of new locomotives, No. 241-A-1, with superheater, four-coupled wheels of 1.8-in. diameter, for Paris-Lyons railway; gave entire satisfaction after running 35,000 km.; comparison with Mikado and Pacific types.

Diesel-Electric. The Future of the Diesel-Electric Locomotive. Ry. Elec. Engr., vol. 17, no. 3, Mar. 1926, pp. 70–74, 2 figs. Discusses effect this type of motive power may have on heavy electric traction. Based on papers presented at meeting of New York sections of four founder engineering societies.

Economizer. Heat-Economic Development of Locomotive with Special Reference to Trial Trips of a

Locomotive Provided with Dabeg Economizer (Wärmewirtschaftliche Entwicklung der Lokomotive, unter besonderer Berücksichtigung von Versuchsfahrten einer mitt Dabeg-Vorwärmer ausgerüsteten Lokomotive), K. Ilhak and Igel. Glasers Annalen, vol. 97, nos. 6 and 10, Sept. 15 and Nov. 15, 1925, pp. 112–119 and 188–193, and vol. 98, no. 5, Mar. 1, 1926, pp. 73–81, 13 figs. Discusses preheating of feedwater by flue gases; describes Dabeg pumps with injection preheater and their use on Austrian locomotives, including test runs made; calculation of water saved by Dabeg pump; test data with Dabeg preheater and with injector.

Eight-Coupled. Eight-Coupled Express Locomotives in France. Ry. Engr., vol. 47, no. 555, Apr. 1926, pp. 119 and 122, 2 figs. Comparative tests on 4-8-2 type, having 4-wheel front truck.

Electric. See ELECTRIC LOCOMOTIVES.

Garratt. The Garratt Locomotive, R. H. Whitelegg. Engineer, vol. 141, no. 3666, Apr. 2, 1926, p. 392. In development of Garratt engine, primary object was not provision of articulated engine as such, but construction of locomotive of high power, embodying boiler having dimensions beyond anything possible in normal rigid type of locomotive without exceeding weight per axle allowed by permanent way. (Abstract.) Paper read before North-East Coast Instn. Engrs. & Shipbldrs.

Headlights. Development of the Locomotive Headlight, J. H. Schroeder. Baldwin Locomotives, vol. 4, no. 4, Apr. 1926, pp. 25–28, 10 figs. Review of development; much success is due to special incandescent lamp now used, capable of standing severe vibration and all other railroad conditions.

High-Pressure. The Ultra-High-Pressure Locomotive. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 75–76, 1 fig. Ultra-high-pressure compound 3-cylinder 4-6-0 superheated-steam express engine for German state railways; developed by Schmidt Superheated Steam Co., Cassel-Wilhelmshohe, Germany.

Industrial Narrow-Gage. Industrial Locomotives (Baulokomotiven), Ewald. Hanomag Nachrichten, vol. 13, no. 147–148, Jan.-Feb. 1926, pp. 1–30, 50 figs. Narrow-gage locomotives from 50 to 280 hp. used for various industrial purposes for mining, canal and other construction work; choice of type for given work, choice of driving power; produced by Hanomag.

Internal-Combustion. Internal-Combustion Locomotives for Railway and Industrial Purposes. Ry. Gaz., vol. 44, no. 10, Mar. 5, 1926, pp. 324–325, 4 figs. Two useful types, manufactured by Crossley Bros., for switching about factory premises and yards.

Main-Rod Reclamation. Reclaiming Locomotive Main Rods, J. Murphy. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 233–234, 4 figs. Rods weakened by repeated reaming operations are restored to original strength by thermit welding.

Mallet. Mallet Locomotives in Logging Service, A. J. Beuter and A. W. Kelly. Baldwin Locomotives, vol. 4, Apr. 1926, pp. 29–37, 18 figs. Review of development and latest types.

Oil-Electric. A Survey of Oil-Electric Locomotive Design, E. M. Speakman. Oil Engine Power, vol. 4, no. 4, Apr. 1926, pp. 210–214, 1 fig. Summary of weight and power data of major units built to date is basis of analytical commentary.

Switching. Eight-Wheel Switchers for the T. & P. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 901–903, 6 figs. With limited cut-off and 250-lb. boiler pressure, tractive force is 54,500 lb.; tender booster on two engines; constructed by Baldwin Locomotive Works. See also Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 216–219, 6 figs.

Three-Cylinder. The Three-Cylinder Locomotive. Ry. Age, vol. 80, no. 16, Mar. 20, 1926, pp. 849–850, 1 fig. Abstracts of papers read before Chicago Section of Am. Soc. Mech. Engrs., as follows: Construction and Economy Features, J. G. Blunt; Some Test Results, E. L. Woodward.

Three-Cylinder Locomotive for the Southern Pacific Ry. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 63–69, 13 figs. Details of construction, including boiler, flange lubricator, lateral-motion adjuster for driving boxes, booster cutout valve; eccentric crank and 6-wheeled tender truck.

Three-Cylinder Superheated Freight Locomotives for the Nigerian Railway. Ry. Engr., vol. 47, no. 555, Apr. 1926, pp. 136–137, 2 figs. General characteristics of these engines are such as to make another new standard for 3-ft. 6-in. gage.

Three-Cylinder Locomotives on the Wabash Railway, W. A. Pawnall. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 81–84, 3 figs. Mikado-type freight locomotive built by American Locomotive Co.

2-10-2. Central of Georgia 2-10-2 Locomotives. Ry. Age, vol. 80, no. 16, Mar. 20, 1926, pp. 869–870. Develops 73,830-lb. tractive force with 190-lb. pressure, 30-in. by 32-in. cylinders and 63-in. driving sheels; built by Baldwin Locomotive Works, Phila.

Valve Gears. Testing Internal Valve Gear of a 3-Cylinder Freight Locomotive of the German Railway (Untersuchung der Innensteuerung der 1 E-Dreizylinder-Güterzung-Lokomotiven der Deutschen Reichsbahn), W. Lipperheide. Glasers Annalen, vol. 98, no. 4, Feb. 15, 1926, pp. 59–65, 18 figs. Shows defects of internal-valve-gear operation by means of new testing method; accurate curves show proper adjustment of slide valve, and whether, in repairing, proper dimensions have been adhered to.

LUBRICATING OILS

Purification. Oil Purification at Kearny Plant, D. F. Miller and R. H. Osgood. Elec. World, vol. 87, no. 16, Apr. 17, 1926, pp. 801–803, 3 figs. Systems for purifying turbine lubricating oil and transformer and circuit-breaker insulating oils at new generating station of Public Service Electric & Gas Co. at Kearny, N. J.

M

MACHINE SHOPS

Foundry. Equip Machines for Large Work, R. A. Fiske. Iron Age, vol. 117, no. 13, Apr. 1, 1926, pp. 899–902, 6 figs. New machine shop of Hubbard Steel Foundry Co., East Chicago, Ind., is located between two foundries; in this shop all castings, with the exception of rolls, are finished.

MACHINE TOOLS

Design Trends. Modern Aims and Tendencies in the Machine-Tool Industry (Neuzeitliche Aufgaben und Ziele des Werkzeugmaschinenbaues), Weil. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 13, Mar. 27, 1926, pp. 437–439. Points out that development of high-speed cutting steels (stellite, hardened steels) for obtaining higher working speed, opens up new problems for machine-tool builders necessitating radical changes in design; hints are given of future trends of design; importance of electrical engineering in machine-tool design; systematic coöperation between electrical engineer and machine-tool builder; problem of special types.

German Standards. Standards for German Machine Tools. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 638, 3 figs. Attempts have been made by German machine-tool builders to standardize direction of movement of all main movable parts of common types of machine tools and to eliminate all unusual motions therefrom.

Modern. Modern Machine Tools. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 99–104, 7 figs. Special features that make for increased production; radial drilling machines; auxiliary high-speed spindle, tilting work tables; center lathes, variable speed headstock, capstan lathes and combination turret lathes; grinding, milling and boring machines.

Selection. How to Select Machine-Tools, W. G. Careins. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 275–278 and (discussion) 278–280. Analyzes concrete factors that should be given consideration in selection of machine equipment.

Small, Heavy Work on. Handling Heavy Work on Small Machines, J. H. Rodgers. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 632–633, 2 figs. Using rollers to support lathe work; extension plate for diesinking machine; compensator for milling machine-table overhang.

MAGNESIUM

Properties. Magnesium and Its Alloys, S. L. Archbutt. Metallurgist (Supp. to Engineer, vol. 141, nos. 3657 and 3661), Jan. 29 and Feb. 26, 1926, pp. 4–6 and 26–30, 10 figs. Data in regard to mechanical properties in cast and wrought state; strength at high temperatures; in specific tenacity at high temperatures cast pure magnesium is shown to exhibit considerable superiority over cast iron.

MALLEABLE CASTINGS

Contraction. The Contraction of Malleable Castings, R. Stotz and F. Henfling. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 38–40, 2 figs. Consideration of shrinkage of white iron such as is used for production of malleable castings. Abstract translated from Stahl u. Eisen, Dec. 31, 1925. (See reference to original article in Eng. Index 1925, p. 465.)

MATERIALS HANDLING

Outside Haulage. Undeveloped Possibilities in Outside Haulage. Factory, vol. 36, no. 3, Mar. 1926, pp. 441–443, 510 and 514, 6 figs. Experiences of large steel mill with electric locomotives; of H. C. White Co. with gasoline locomotives; of Wilson Foundry & Machine Co., with tractor-trailers; and of Fedders Mfg. Co., with semi-trailers.

[See also ASH HANDLING; COAL HANDLING; FOUNDRIES; FREIGHT HANDLING.]

METAL SPRAYING

Application. Use of Metal Spraying Process in Transportation Industry (Die Verwendung des Metallspritzverfahrens im Verkehrswesen), G. Kutscher. Verkehrstechnik, no. 8, Feb. 19, 1926, pp. 123–128, 5 figs. Details of process; spray pistols; application to exterior and interior of boilers, etc.; extensive use for coating with zinc, also with preliminary aluminum coating.

METALS

Fatigue. On the Concentration of Stress in the Neighborhood of a Small Spherical Flaw; and on the Propagation of Fatigue Fracture in "Statistically Isotropic" Materials, R. V. Southwell and H. J. Gough. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. of Sci., vol. 1, no. 1, Jan. 1926, pp. 71–97, 12 figs. Concentration produced by small spherical flaw in material subjected to uniform tension; effect of small spherical flaw in twisted shaft; origin of fatigue fractures.

What Happens When Metal Fails by Fatigue? H. F. Moore. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 539–552, 4 figs. Presents picture of what happens when metal fails by fatigue under repeated stress; also pictures two actions going on in metal under repeated stress; one strengthening and the other destructive action; if destructive overbalances strengthening action, metal will fail.

Plastic Deformation. Plastic Formation (Plastische Gestaltung), P. Schweissguth. Maschinenbau, vol. 5, no. 3, Feb. 4, 1926, pp. 105–109, 6 figs. Discusses classification of plastic deformations: forging, rolling, cold drawing, and spraying; connection between rolling and forging, conception of plasticity, and of forging; kinds of forging and subdivisions.

Processes of Plastic Deformation (Ueber die Vorgänge bei der bildsamen Formänderung), H. Hoff and G. Sobbe. Maschinenbau, vol. 5, no. 3, Feb. 4, 1926, pp. 109–112, 16 figs. Discusses conception of plasticity, and reviews literature as to present knowledge regarding compression of plastic bodies and forms they assume in consequence.

The Mechanism of Plastic Deformation, Meyer and Nehl. Metallurgist (Supp. to Engineer, vol. 141, no. 3661), Feb. 26, 1926, pp. 23–25, 3 figs. Comprehensive résumé of existing theories, from critical study of which they have been able to advance explanation which appears to fit experimental facts, and which they support by results of numerous experiments. Abstract translated from Stahl u. Eisen, Nov. 1925.

Porosity. The Porosity of Metals. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 41–42. Results of experiments carried out by Tammann and Bredemeyer on such widely varied materials as copper, brass, steel and cast iron, showing that water, applied under pressure, penetrated to very considerable depth. (See reference to original article in Eng. Index 1925, p. 478, under METALS, Hollow Channels.)

Stress and Strain Hardness. The Mechanics of Metals (Vorbilder für die Metallmechanik), F. Rinne. Zeit. für Metallkunde, vol. 18, nos. 2 and 3, Feb. and Mar. 1926, pp. 37–42 and 81–84, 34 figs. Discusses phenomena of stress, plastic deformation, strain hardness and fracture; author's optical and X-ray examinations are confined mainly to materials, such as rock salts, which are physically similar to metals, but possess advantage of being transparent and can therefore act as model; describes structural conditions of primary and secondary stress, whereby changing positions of and changes in atoms play important role; stresses due to isomorphous mixture; strain hardness is said to be due to coarsening of textures.

MILLING

Cam. Use of Dividing Head and Circular Attachment for Cam Milling. Machy. (Lond.), vol. 27, no. 702, Mar. 11, 1926, pp. 765–766, 2 figs. Index plate of dividing head should have proper number of holes to give angular divisions obtained by dividing total angles of cam rotation by number of cuts to be taken; tabulation of indexing of circular table or number of holes between cuts, etc., which should be furnished to machinist.

MILLING MACHINES

Double-Overarm. Double Overarm Milling Machine. Brit. Machine Tool Eng., vol. 3, no. 37, Jan.-Feb., 1926, pp. 369–370, 2 figs. Type of overarm employed on Parkinson machine consists of 2 cylindrical arms carried side by side so that centers of arms and centers of spindle form triangle.

Duplex. Full Automatic Table Control a Feature of New Milling Machine. Automotive Industries, vol. 54, no. 12, Mar. 25, 1926, pp. 538–540, 4 figs. Production miller brought out by Brown & Sharpe is of 2-spindle type; adapted for full automatic, part automatic and intermittent table operation; uses variety of fixtures.

High-Production Milling Machine. Iron Age, vol. 117, no. 12, Mar. 25, 1926, pp. 842–843, 3 figs. Full automatic table control is feature of new duplex machine, manufactured by Brown & Sharpe Mfg. Co., Providence; design permits use of wide variety of fixtures and attachments.

MOLDING MACHINES

Drive. Belt or Direct Electric Drive for Moulding Machines. Elec. News, vol. 35, no. 5, Mar. 1, 1926, pp. 49–51, 4 figs. Results of tests show startling reduction of costs with latter, accompanied by increased production.

MOLDING METHODS

Loam. Describe Loam Molding Methods, B. Shaw and J. Edgar. Foundry, vol. 54, nos. 5, 6 and 7, Mar. 1, 15, and Apr. 1, 1926, pp. 184–187, 225–228 and 275–279, 44 figs. Alternative method presented by which core is built directly in lower half of mold. Mar. 15: Various methods and devices adopted to make cores for irregular shapes. Apr. 1: Essential features of propeller-wheel mold.

Plate. The Latest Improvements of the Bonvillain Method for the Production of Cast Molding Plates (Die jüngsten Vervollkommungen des Bonvillainschen Verfahrens zur Herstellung gegossener Formplatten), C. Irresberger. Stahl u. Eisen, vol. 46, no. 12, Mar. 25, 1926, pp. 397–400, 14 figs. Discusses four main types of cast molding plates.

MOLDS

Formed with Cores. More Moulds Made with Cores, Caster. Metal Industry (Lond.), vol. 28, no. 10, Mar. 5, 1926, pp. 229–231, 10 figs. Supplement to series of article published in same journal in 1925, giving further interesting examples of construction of molds entirely or mainly from cores.

Gases from Molten Iron. Gases Evolved from Heated Iron, B. Hird. Foundry Trade Jl., vol. 33, no. 500, Mar. 18, 1926, pp. 219–221, 13 figs. Experiments to discover nature of gas which is given off from solid pieces of iron when their temperature is raised; this frequently occurs when nails, studs, chaplets, pieces of bar or pipe, chills or denseners are placed in molds and their temperature raised by pouring molten iron around them.

Permanent. Permanent Molds. Foundry Trade Jl., vol. 33, no. 497, Feb. 25, 1926, p. 156, 1 fig. New process of permanent mold cast-iron casting manufacture, consisting in provision of mold, facing of which consists of special refractory material which does not adhere to iron and strips so cleanly that beyond reblacking is suitable for recording and closing ready for reception of liquid metal.

Traces Steps in Long Life Mold Advance, H. Schwartz. Foundry, vol. 54, nos. 2, 3, 4 and 5, Jan. 15, Feb. 1, 15 and Mar. 1, 1926, pp. 42–44 and 76, 92–94, 147 and 149–150, and 189–192, 7 figs. Theory on which process is based, together with intimate details of construction and operation of molds. Feb. 1: Phases of mold deterioration; method of maintaining temperature of mold within certain predetermined temperature range. Feb. 15: Cooling velocity of permanent mold accelerated or retarded to secure hardness characteristics of castings. Mar. 1: Results obtained on batteries of permanent molds engaged in making automotive parts in modern production foundry.

Venting. Venting. Metal Industry (Lond.), vol. 28, no. 9, Feb. 26, 1926, pp. 205–206, 5 figs. Discusses dangers of misuse of vent wire, and points out how use of suitable facing sand and skill of molder will often avoid much artificial venting; describes job illustrating certain difficult problems in venting.

MOTOR BUSES

Brakes. Brakes for Heavy Vehicles, L. C. Huck. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 288–295 and (discussion) 295–298, 6 figs. Through mathematical analysis, author determines effect of self-actuation measured in terms of increase or decrease of cam pressure required to sustain same normal pressure before and after outside torque has been applied to brake drum; defines terms "actuation factor" and "actuation constant," and determines their values under different conditions; author concludes that in order that any braking system may operate efficiently, the linkage must be rigid and its geometry must be correct.

Design Changes. Motorcoach Builder's Attitude Toward Changes in Standard Designs, E. W. Templin. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 379–383, 1 fig. Consideration of requests which have been made for changes relating to type and make of headlights, clutch design, generator size and mounting, carburetor, lubricating system, steering columns speedometer, body parts.

Epicyclic Gears. Magnetically Controlled Epicyclic Gear. Motor Transport (Lond.), vol. 42, no. 1099, Mar. 22, 1926, pp. 349–350, 4 figs. Details of total transmission now being tested on Paris omnibuses as solution of driver problem.

Gasoline-Electric. An Electric Drive for Gasoline-Propelled Motorbuses. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 359–365. Discussion of paper by H. S. Baldwin, published in July 1925, issue of journal. See reference to original paper in Eng. Index 1925, p. 501.

Electrical Equipment for Gas-Electric Railless Vehicles, C. K. Lee. Elec. Jl., vol. 23, no. 3, Mar. 1926, pp. 136–142, 7 figs. Discusses different forms of gas-electric equipment on market; braking; series connection; operating results, and probable future.

New Fageol Gas-Electric Chassis Has Westinghouse Drive. Automotive Industries, vol. 54, no. 10, Mar. 11, 1926, pp. 440–441, 4 figs. Two electric motors and Hall-Scott six-cylinder engine form power plant; specially designed steel body used; maximum road speed, 35 m.p.h.

Operating Experience with Gasoline-Electric Motorcoaches. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 373–377. Discussion of paper by R. H. Horton, published in Dec. 1925, issue of journal. See reference to original paper in Eng. Index 1925, p. 501.

Studebaker. A New Studebaker Saloon Coach. Motor Transport (Lond.), vol. 42, no. 1098, Mar. 15, 1926, pp. 237–329, 8 figs. Particulars regarding a six-cylinder medium-capacity vehicle with hydraulic 4-wheel brakes.

MOTOR-TRUCK TRANSPORTATION

Water-Terminal Operation and. Relation of the Motor Truck to Water Terminal Operation, W. F. Williams. World Ports, vol. 14, no. 5, Mar. 1926, pp. 49–54 and (discussion) 54–75. Discusses relation of motor vehicle to development of water-terminal business as applied in particular to Commonwealth Pier 5 in port of Boston.

MOTOR TRUCKS

Crossley-Kegresse. A Crossley-Kegresse 1-Tonner. Motor Transport (Lond.), vol. 42, no. 1097, Mar. 8, 1926, pp. 299–300, 4 figs. Recently introduced light chassis adopted for cross-country service; engine is of 4-cylinder monobloc type combined as one unit with single dry-plate clutch and right-hand controlled 4-speed gear box, whole flexibility supported at 3 points in frame.

German. German Motor Trucks (Nutzfahrzeuge), Automobil-Rundschau, vol. 28, no. 1, Jan. 1, 1926, pp. 5–10, 14 figs. Details of trucks at German automobile show; overhead camshafts seem to be giving place either to L-head or to overhead valves with push-rod drive; use of electron pistons in Magirus and Mannesmann-Mulag trucks; truck motor brake produced by Henschel u. Sohn, Kassel; solid-injection Diesel engine of M.A.N. works; trucks by Krupp, N.A.G., etc.

Lubrication. The Essentials of Industrial Truck and Tractor Lubrication, A. F. Brewer. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 247–252, 12 figs. Discusses lubrication requirements of chassis parts and final drives, etc., of various modern types of industrial tractors and trucks.

Operating Cost. Operating Costs and Economic Life of Motor Vehicles, W. H. Fairbanks. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 285–287. Table summarizing operating costs of large mixed fleet for one year shows how records reveal highly important fundamental facts; relation of mileage to operating costs; methods of determining economic life of truck.

O

OIL ENGINES

Double-Acting. Double-Acting Engine of Wide Application. Oil Engine Power, vol. 4, no. 4, Apr. 1926, p. 215, 1 fig. Type now nearing completion at New London is 2-cylce design consisting of massive bedplate with cast-iron columns, guides, slippers, etc., in accordance with modern marine practice.

High-Efficiency. The High Efficiency Oil-Engine, A. E. L. Chorlton. Engineering, vol. 121, no. 3143, Mar. 26, 1926, pp. 409–411, 9 figs.; also Engineer, vol. 141, nos. 3665 and 3666, Mar. 26 and Apr. 2, 1926, pp. 364–366 and 394–395, 9 figs. Points out that main line of development has always been by increase of compression or expansion ratio, and suggests that it is in this direction that further progress is still possible; mechanical losses in internal-combustion engines; effect of speed on thermal efficiency; atomization; brief description of quick-running engine manufactured by Wm. Beardmore & Co. (Abstract.) Paper read before Instn. Mech. Engrs.

Junkers Opposed-Piston. The New Junkers Two-Stroke Engine (Der neue Doppelkolben-Zweitaktmotor von Professor Junkers), Schmolke. Wärme, vol. 49, no. 2, Jan. 8, 1926, p. 29, 1 fig. Engine is of opposed-piston type, with solid injection of oil through one or more nozzles when pistons are on their inner dead centers and space between them is filled with highly compressed air; shortly before outer dead centers are reached, exhaust and scavenging ports are opened; smooth surface of cylindrical space between pistons results in thorough scavenging and minimum transfe of heat before commencement of working stroke; use of opposed pistons facilitates balancing of engine; fuel consumption in larger engines is said to be only 0.35 lb. per b.hp. per hr.

M.A.N. The M.A.N. Double-Acting Marine Oil Engine. Engineer, vol. 141, nos. 3665 and 3666, Mar. 26 and Apr. 2, 1926, pp. 352–354 and 356, and 382–384. 9 figs. New engine operates on 2-cycle principle, with port scavenging, and is designed to develop 4400 b.hp. in 6 cylinders, when running at comparatively low speed of 84 r.p.m.; results obtained during recent tests; future development of this new type.

Mirrlees-Nobel. A Mirrlees-Nobel Marine Heavy-Oil Engine of 1000 B.H.P., Mar. Engr. & Motorship Bldr., vol. 49, no. 583, Mar. 1926, pp. 104–105, 1 fig. 4-cylinder, 2-stroke-cycle engine, designed to produce 1000 b.hp. at 125 r.p.m.

OIL FUEL

Combustion. Experience with the Combustion of Fuel Oil in Power Plant Boilers, J. F. Barkley. U. S. Bur. of Mines—Reports of Investigations, no. 2730, Feb. 1926, 6 pp., 1 fig. Also Oil & Gas Jl., vol. 24, no. 44, Mar. 25, 1926, pp. 90 and 92. Results of studies and tests made of various oil-burning equipments under power-plant boilers.

Specific Gravity and Viscosity. The Graphic Relation of Specific Gravity to Viscosity in the Case of Fuel Oils, G. B. Vroom. Am. Soc. Naval Engrs.—Jl., vol. 38, no. 1, Feb. 1926, pp. 119–129, 5 figs. Shows how, specific gravity and viscosity at known temperatures being given, its viscosity at any other temperature may be predicted within sufficiently accurate limits for practical working purposes.

OPTICAL INSTRUMENTS

Gaging Devices. New Projection Device for Testing Fine Bores (Neuartiger Projektionspparat zum Prüfen feiner Bohrungen), O. Lich. Praktischer Maschinen-Konstrukteur, vol. 59, no. 5–6, Feb. 6, 1926, pp. 57–58, 6 figs. Device by Zeiss in Jena for testing roundness and proper dimensions to an accuracy of 0.00025 mm. or more.

Tooling Work. Accurate Angles by Optical Methods, F. C. Hudson. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 601–602, 4 figs. Simple and very accurate method of setting work at right angles, that can be used on any toolroom job.

Zeiss Measuring Machine. Zeiss Measuring Machine. Machy. (Lond.), vol. 27, no. 703, Mar. 18, 1926, pp. 815–816, 5 figs. Details of design; principle of optical system.

OXYACETYLENE WELDING

Applications. Oxygen the Wonder Worker, H. L. Rogers. Southern & Southwestern Ry. Club—Proc., vol. 18, no. 7, Jan. 1926, pp. 10, 13, 14, 17, 18, 21, 22 and 25 and (discussion) 25, 26, 29, 30, 33, and 34. Oxyacetylene welding torch and principle; oxyacetylene cutting torch; welders and cutters; application to railway work.

Cast-Iron Heater Sections. Procedure Control for Oxyacetylene Welding Cast Iron Heater Sections, J. W. Haygood. Am. Welding Soc.—Jl., vol. 5, no. 2, Feb. 1926, pp. 7–11. Selection and inspection of material; design and layout of welded joint; preparation of piece for welding; welding technique; inspection and test.

Copper. Oxy-Acetylene Welding of Copper, S. W. Miller. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 639–640, 4 figs. Introduction of silicon as deoxidizer in metal being welded as well as in welding rod results in production of sound welds.

P

PARACHUTES

Civilian and Airship. Civilian and Airship Parachutes, H. S. Holt. Aeroplane, vol. 30, no. 12, Mar. 24, 1926, pp. 316, 318 and 320, 5 figs. Discusses problems for passengers not exceeding four on open machines, and for passengers on large air liners with covered-in saloons.

PIPE, CAST-IRON

Bronze Welding. Bronze Welding of Cast Iron Pipe, H. Y. Carson. Acetylene Jl., vol. 27, no. 9, Mar. 1926, pp. 429–435, 9 figs. Results of tests; practical bronze-welding data. Paper presented before Gas Products Assn.

Centrifugally Cast. Centrifugally-Cast Pipes at the Works of the Stanton Ironworks Company, Limited. Iron & Coal Trades Rev., vol. 112, no. 3029, Mar. 19, 1926, pp. 479–482, 13 figs. Methods and equipment of plant installed at Stanton Works near Nottingham, Eng., employing de Lavaud process.

Corrosion. Factors Other Than Dissolved Oxygen Influencing the Corrosion of Iron Pipes, J. R. Baylis. Indus. & Eng. Chem., vol. 18, no. 4, Apr. 1926, pp. 370–380, 13 figs. Investigation, which has been under way for several years, covering several phases of problem; electrochemical theory of corrosion; solubility of ferrous hydroxide and of ferrous carbonate; compounds formed in corrosion of iron; examination of question as to whether ferrous hydroxide precipitates during corrosion; influence of negative ions; pitting and tuberculation.

PISTONS

Aluminum. Aluminum Pistons (Der Aluminiumkolben im Fahrzeugmotor), C. Steiner. Motorwagen, vol. 29, nos. 1 and 3, Jan. 10 and 31, 1926, pp. 8–9 and 52–55, 16 figs. Author is of opinion that it is difficult to avoid play of piston pins in piston bosses since aluminum expands so much more than steel; he therefore recommends floating pins so proportioned that bearing pressure in bosses will not exceed 2500 lb. per sq. in. when explosion pressure is 450 lb.; a good thing is to cast steel bushings into bosses; stress of 15,000 to 18,000 lb. per sq. in. is permissible in bending for good fine-grained cast iron for rings. Comparison of efficiency and fuel consumption with aluminum and with gray-cast-iron pistons.

Manufacture. Piston Methods, F. H. Colvin. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 581–583, 14 figs. Methods and sequence of operations and devices used; burnishing ring grooves, grinding relief and facing pistons to length.

PLANERS

Testing Gears. Testing Planer Gears, C. E. Linden. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, p. 650, 3 figs. Use of special testing fixture may be employed with all large spur, helical, or herringbone gears.

PLATES

Flat Circular, Vibrations in. The Frequencies of Vibration of Flat Circular Plates fixed at the Circumference, H. Carrington. Lond., Edinburgh, & Dublin Philosophical Mag. & Jl. of Sci., vol. 50, no. 300, Dec. 1925, pp. 1261–1264. Gives equations and tables for frequencies of transverse symmetrical vibration of fixed circular plate.

Rectangular, Calculation of. Calculating Flat Rectangular Plates (Calcul des plaques rectangulaires planes), R. Lemaitre. Revue Universelle des Mines, vol. 9, no. 2, Jan. 15, 1926, pp. 58–80, 6 figs. Calculation of plates supported at their circumference and subjected to uniform load per unit.

Ripping up, Machine for. A Large Plate Ripping Machine. Engineer, vol. 141, no. 3664, Mar. 19, 1926, p. 333, 9 figs. partly on pp. 326 and 332. Machine employed for ripping up steel plates required for construction of Sydney Harbor bridge; it can accommodate plates up to 5 ft. in width and 67 ft. in length, and is capable of ripping them from end to end.

POWER

Purchased vs. Generated. Whether to Buy Power or Make I, J. Breslove. Iron Age, vol. 117, no. 18, May 6, 1926, pp. 1259–1263, 6 figs. Question of buying power or making it revolves around internal conditions in each plant; when steam is required for process work or other special conditions prevail, actual cost of power itself becomes of secondary importance; author discusses these points and tells how one plant attacked problem and found its solution.

PULVERIZED COAL

Gyro Gasification Systems. Installations of a New Pulverized Fuel System E. K. Scott. Combustion, vol. 14, no. 4, Apr. 1926, pp. 250–253, 3 figs. Firing equipment installed on Gyro gasification system at power stations of West Ham Corp. and Dover Corp.

Limitations and Comparisons. Some Limitations and Comparisons, E. W. L. Nicol. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 57–61, 3 figs. Discusses whole question of advantages from an impartial standpoint, and explains systems at present in operation.

PUMPING STATIONS

Design Problem. Pumps, Power and Stations, R. W. Angus. Can. Engr., vol. 50, no. 10, Mar. 9, 1926, pp. 51–52 and (discussion) 53–54, 4 figs. Vertical triple-expansion engines; centrifugal and single-stage pumps; high-speed low-head pump; steam turbines and electric motors; standby units. Paper read before Can. Section, Am. Water Wks. Assn.

Power Generation for. Steam, Oil and Electric Power, E. A. Allcut. Can. Engr., vol. 50, no. 10, Mar. 9, 1926, pp. 54–56. Review of present practice and possible future developments in generation of power for pumping plants.

PUMPS

Air-Lift. Air Lift Pumps (Druckluft Wasserheber), F. Dabrowski. Zeit. des Oberschlesischen Berg- u. Hüttenmännischen Vereins Zu Katowice, vol. 65, no. 1, Jan. 1926, pp. 13–24, 9 figs. Describes "Mammut"

pump used in mining, operation and calculation of performances; amount of air consumed per unit of volume, initial and final velocity of flow; comparison of Borsig and Sullivan systems.

PUMPS, CENTRIFUGAL

Automatic Control. A Few New Minor Changes Improve Automatic Pumping Service, E. J. Gealy. Coal Age, vol. 29, no. 9, Mar. 4, 1926, pp. 323–324, 3 figs. Details of improvements which have simplified and perfected operation of original automatic features.

Recent Improvements in Automatic Centrifugal Pump Control Simplify Apparatus, R. S. Sage. Coal Age, vol. 29, no. 9, Mar. 4, 1926, pp. 321–322, 1 fig. Time-delay relay takes place of notching type; adjustments are made to suit pumping conditions; in case of trouble pump is locked out of service.

Impellers, Water-Pressure Distribution in. Experimental Research on the Distribution of Water Pressure in a Centrifugal Pump Impeller, S. Uchimaru, Faculty of Eng., Tokoyo Imperial Univ.—Jl., vol. 16, no. 6, Sept. 1925, pp. 157–169, 65 figs. partly on supp. plates. Result of experiment to determine variation of water pressure at different points in impeller channel when rotating and delivering water.

R

RADIATION

Direct. Heat Emission, Heating Effect and Heating Efficiency of Direct Radiation, K. Meier. Am. Soc. of Heat. and Vent. Engrs.—Jl., vol. 32, no. 3, Mar. 1926, pp. 159–163. Heat emission as found by condensation and expressed in B.t.u. represents capacity of radiator under stated working conditions; heating effect is a quality more or less variable; heating efficiency is degree of utilization which may be stated in percentages; as generally understood it is ratio between heat actually utilized and that contained in fuel.

RAILS

Detecting Defects in. Track Device for Detecting Defects in Rails, M. Suzuky. Eng. News-Rec., vol. 96, no. 13, Apr. 1, 1926, pp. 520–522, 4 figs. To detect and locate in rails in track such internal defects as transverse fissures, spots affected by abnormal stresses and segregation of impurities, portable magnetic apparatus has been devised by Japanese engineers, which utilizes magnetic induction by leakage magnetic-flux method and is known as defectoscope.

RAILWAY ELECTRIFICATION

Chicago. Chicago Terminal Electrification on the Illinois Central, D. J. Brumley. Eng. News-Rec., vol. 96, no. 8, Feb. 25, 1926, pp. 322–326, 3 figs. Terminal and lake-front improvements; passenger stations and freight yard; overhead wire system; suburban-train equipment.

RAILWAY MANAGEMENT

Stores Department. Delaware & Hudson Has Well Equipped Store Department. Ry. Age, vol. 80, no. 19, Apr. 10, 1926, pp. 1015–1018, 6 figs. Radial scrap dock cuts sorting costs to new low record of 34 cents a ton; gantries for lumber handling.

RAILWAY MOTOR CARS

Benzol. Railway Motor Cars for Freight Traffic (Benzoltriebwagen für Güterverkehr), E. Heintz. Fördertechnik u. Frachtverkehr, vol. 19, no. 6, Mar. 19, 1926, pp. 77–80, 5 figs. Efforts of Daimler, Deutsche Werke, and A. E. G. to produce satisfactory car and gearing for a speed of 35 kw-hr.

Gasoline-Electric. A 73-Foot Gas Electric Car for Boston and Maine. Ry. Elec. Engr., vol. 17, no. 4, Apr. 1926, pp. 109–110, 4 figs. Control circuits and 760-watt lighting load supplied by 215 ampere-hour battery and 2.5-kw. exciter.

Large Gas-Electric Car for the Boston & Maine, T. H. Murphy. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 911–913, 4 figs. Car which is 73 ft. long and seats 92 passengers will meet service requirements without trailer.

Germany. A new Gasoline Motor Car of the German Railway (Ein neuer Benzin-Triebwagen der Deutschen Reichsbahn-Gesellschaft), P. Friedmann. Verkehrstechnik, vol. 43, no. 12, Mar. 19, 1926, pp. 192–195, 5 figs. Car built by Waggon & Maschinenbau A. G. at Görlitz, with six-cylinder Büssing engine developing 90 hp. at 1000 r.p.m. and automatic speed-change mechanism and reversing gear.

A Year's Operating Experience with Railway Motor Cars on the Südstormarn Line (Ein Jahr Triebwagenbetrieb auf der Südstormarnschen Kreisbahn), R. Sieber. Verkehrstechnik, vol. 43, no. 11, Mar. 12, 1926, pp. 173–176, 3 figs. Experience with gasoline-driven car shows that, compared with steam, its cost was 91 per cent with trailer and 72 per cent without trailer, but that with 100 kg. gasoline equal in price to 2500 kg. rich coal, costs are equal.

Maintenance. Methods of Maintaining Motor Cars. Ry. Rev., vol. 78, no. 11, Mar. 13, 1926, pp. 514–519, 2 figs. Abstract. Report of subcommittee of Committee of Economics of Railway Labor, Am. Ry. Eng. Assn.

Mechanical Transmission. Smalley Rail Car Mechanically Driven Through Herringbone Gears, P. M. Heldt. Automotive Industries, vol. 54, no. 13, Apr. 1, 1926, pp. 566–567, 3 figs. Powered by 2 Climax 4-cylinder engines which develop 76 hp. at 1200 r.p.m.; gear changes effected with Campbell sliding-key arrangement; radiator fan driven by spur gears.

RAILWAY OPERATION

A.R.E.A. Report. Report of Committee XXI—Economics of Railway Operation. Am. Ry. Eng. Assn.—Bul., vol. 27, no. 284, Feb. 1926, pp. 733–757, 15 figs. Effect of speed of trains upon cost of transporting freight; method of increasing traffic capacity of railway; effect of installing automatic signals. See also (abstract) in Ry. Age, vol. 80, no. 14, Mar. 12, 1926, pp. 760–764.

Train Control. Train Control Devices Approved. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 908–910. Interstate Commerce Commission approved 2-speed continuous-induction train-control system of Union Switch & Signal Co., as installed on Wyoming division of Union Pac. and also approved with certain exceptions automatic train-stop system of Nat. Safety Appliance Co. on Central Kansas Division of Missouri Pac.

Train Control Instruction and Inspection. Ry. Elec. Engr., vol. 17, no. 4, Apr. 1926, pp. 122–123, 4 figs. Tracks employed in maintenance program of Richmond, Fredericksburg and Potomac.

RAILWAY REPAIR SHOPS

Driving-Box Repairs. Driving Box Practice at the C. & N. W. Shops, F. W. Curtis. Am. Mach., vol. 64, no. 13, Apr. 1, 1926, pp. 501–504, 11 figs. Methods of special details for driving-box repairs employed in Chicago shops.

Equipment. How Railroad Repair Shops Are Equipped. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 586–587, 2 figs. Statistical analysis of types of equipment and their relative ages.

Locomotive. Handling Locomotive Repairs to Meet a Scheduling System, F. W. Curtis. Am. Mach., vol. 64, no. 11, Mar. 18, 1926, pp. 433–436, 12 figs. Methods employed at Silvis Shops of Chicago, Rock Island & Pac. Ry.

Santa Fe Completes Reconstruction of Coast Line Shops. Ry. Age, vol. 80, no. 19, Apr. 10, 1926, pp. 1001–1009, 14 figs. Locomotive repair plant at San Bernardino is rebuilt on enlarged scale and fully equipped with latest labor-saving machinery.

Passenger-Car. General Layout and Design of Passenger Car Shops. Ry. Rev., vol. 78, no. 11, Mar. 13, 1926, pp. 508–513, 4 figs. Abstract. Report of subcommittee of shops and locomotive terminals, Am. Ry. Eng. Assn.

RAILWAY SIGNALING

Color-Light Signals. Color-Light and A. C. Floating Change-Over on the Burlington. Ry. Signaling, vol. 19, no. 4, Apr. 1926, pp. 152–154, 4 figs. Primary batteries and lower quadrant double-arm semaphore signals removed between Chicago and Aurora.

Four-Aspect Colour Light and Power Signaling Southern Railway. Ry. Gaz., vol. 44, no. 13, Mar. 26, 1926, pp. 456–461, 11 figs. Describes how system, in association with electric power signaling, has been practically applied.

Four-Aspect Colour Light Signals. Ry. Gaz., vol. 44, no. 11, Mar. 12, 1926, pp. 359–361, 1 fig. Application to Southern Railway (England) suburban routes.

RAILWAY SWITCHES

Car Retarders. Electro-Pneumatic Car Retarders in Service on Illinois Central. Ry. Signaling, vol. 19, no. 4, Apr. 1926, pp. 137–141, 11 figs. Installation of Union Switch & Signal Co., equipment on northbound classification yard at Markham largest in world.

REFRIGERATING MACHINES

Domestic. Efficiency Test of Domestic Refrigerators. Ice & Refrigeration, vol. 70, no. 3, Mar. 1926, pp. 305–310, 12 figs. Results of series of tests conducted at laboratories of Armour Institute of Technology, Chicago, in which 10 refrigerators were used, all identical in shape, size and workmanship with exception of heat-insulating material used in walls.

REFRIGERATING PLANTS

Brine Handling in Coolers. Handling Brine in Coolers and Spray Systems, J. F. Staley. Power Plant Eng., vol. 30, no. 7, Apr. 1, 1926, pp. 440–442, 2 figs. Discusses operation of coolers for both salt and calcium brine, layout of brine spray system and design of brine evaporator.

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SCREW MACHINES

End-Knurling Tools for. End-Knurling Tools for Screw Machine, H. Simon. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 609–612, 5 figs. Problems involved in designing tool equipment; making knurls; developing knurl-roll holder; preparing work for knurling.

SCREW THREADS

Tangential Cutting. Thread Cutting by Means of Tangential Detachment of Chips With Rotating Self-Opening Screwing Chucks (Das Schneiden von Gewinden durch tangentiale Spanabhebung mittels umlaufenden, selbstöffnenden Schneidkopfes), R. Meininger. Maschinenbau, vol. 5, no. 4, Feb. 18, 1926, pp. 167–170, 15 figs. Differences in principles of radial and tangential cutting; radial and tangential cutting heads; thread cutting with various pitches; left-handed threads.

SEAPLANES

De Havilland. Seaplane for G. G. of Australia. Flight, vol. 18, no. 13, Apr. 1, 1926, pp. 188–190, 4 figs. D.H. 50 has been fitted with duralumin floats built at works of Short Bros., Rochester, Eng.

Large. Recent Experiments with Large Seaplanes, A. Rohrbach. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 353, Mar. 1926, 33 pp., 15 figs. on supp. plate. Account of what has been accomplished in author's companies, demonstrating correctness of his views of increasing size of airplanes; advantages of heavy wing load; wing structure; maximum strength with minimum weight; safety in event of injury of important parts; easy accessibility of every structural part; inexpensive manufacture. Translated from Berichte und Abhandlungen der Wissenschaftlichen Gesellschaft für Luftfahrt.

Short Mussel. The Short S. 7 Mussel. Flight, vol. 18, no. 10, Mar. 11, 1926, pp. 141–145, 15 figs. Designed for use as light training machine; seaplane which can be turned into landplane by substituting wheel under carriage and tail skid for twin-float undercarriage; equipped with A.D.C. Cirrus 4-cylinder air-cooled engine. See also Aeroplane, vol. 30, no. 10, Mar. 10, 1926, pp. 266–267, 2 figs.

SHAFTS

Vibrations. Graphical Method of Determining Torsional Vibrations in Shafts (Zeichnerisches Verfahren zur Bestimmung der Torsions-Eigenschwingungszahlen von Wellen), P. Kohn. Maschinenbau, vol. 5, no. 5, Mar. 4, 1926, pp. 220–221, 3 figs. Method for determining torsional period of vibrations which is comparatively simple.

STANDARDIZATION

Germany. German Standardization Work (Die deutschen Normungsarbeiten), F. Neuhaus. Technik u. Wirtschaft, vol. 19, no. 1, Jan. 1926, pp. 31–34, 4 figs. Development of German Industrial Standards Committee (N. D. I.) and its work of standardizing and reduction of types; difficulties in adoption of standards; specialization by firms in standard articles, etc.

Variety Through. Variety Through Standardization, C. E. Skinner. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 327–329. Nature's use of standards; electrical industry as illustration of value of standardization; work already done in industrial standardization; work of Am. Eng. Standards Committee in national and international standardization; scope of and necessary limitations.

STEAM

High-Pressure. High-Pressure Steam in Industrial Plants, A. F. Sheehan. Power, vol. 63, no. 16, Apr. 20, 1926, p. 606. Advantages when process steam is needed; higher installation costs.

STEAM ENGINES

Corliss. Largest Corliss Engine in Twenty Years. Power, vol. 63, no. 12, Mar. 23, 1926, pp. 441–442, 4 figs. Twin tandem engine capable of developing maximum of 15,000 hp. at 200-lb. steam pressure is being installed for rope drive at one of large steel mills.

High-Pressure. A High-Pressure Quadruple-Expansion Engine. Shipbldg. & Shipg. Rec., vol. 27, no. 11, Mar. 18, 1926, pp. 328 and 335. Details of new set of engines and boilers, intended for propulsion of 11-knot cargo steamer, built by Central Marine Engine Wks.

STEAM PIPE

Cost Estimation. Estimating Fabricated Pipe Costs, I. A. Butcher. Power, vol. 63, nos. 11 and 12, Mar. 16 and 23, 1926, pp. 414–416 and 443–445, 8 figs. Method by which it should be possible for engineer to estimate power-plant piping. Mar. 16: Compares cost of gas-welded pipe work with fitting job. Mar. 23: Cost of cutting and threading operations, pipe joints, pipe bending, etc.

STEAM POWER PLANTS

Combined Heating and Generating. Combination Power and Heating Plants in North Bohemia, J. H. D. Blanke. Nat. Engr., vol. 30, no. 3, Mar. 1926, pp. 97–101, 4 figs. Review of recent developments in this field in Germany and Czechoslovakia; problems of exhaust-steam utilization and coöperation with central-station power systems worked out; translated from Zeit. des Vereines deutscher Ingenieure, June 27, 1925.

Cost Analysis. Power Plant Costing, C. H. S. Tupholme. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 48–51, 3 figs. How various costs incurred in factory power house should be allocated in works account system.

Production Cost in Private Plant Operation, E. Winholt. Nat. Engr., vol. 30, no. 3, Mar. 1926, pp. 95–96. Practical illustration of cost analysis and factors chargeable to cost of service.

Design. Designing a 500-Horsepower Steam Power Plant, C. L. Hubbard. Southern Power Jl., vol. 44, no. 3, Mar. 1926, pp. 50–55, 8 figs. Making preliminary layout of plant, showing space required and general arrangement of building in its different parts.

Operation. The Economical Operation of the Power Plant, W. D. Wylde. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 39–48, 15 figs. Exhaustive survey of appliances and names available by which economics may be effected in power house, and whereby high state of efficiency can be obtained and maintained continuously throughout production and utilization of power irrespective of type or size of plant concerned.

Piping. Industrial Power Plant Piping, T. Maynz. Chem. and Met. Eng., vol. 33, no. 4, Apr. 1926, pp. 229–230. Design and upkeep of pipe lines for water, steam and air with reference to expansion, heat losses and other important factors.

Western Electric Co., Kearny, N. J. Western Electric Co.'s Power Plant at New Kearny Works. Power, vol. 14, Apr. 6, 1926, pp. 514–518, 8 figs.

has advantages of being simple and comparatively inexpensive and of giving ordinary pencil diagrams on paper cards, although it can be used for indicating engines running at 5000 r.p.m., or at even higher speeds; essential feature is employment of two concentric cylindrical rotary valves between engine cylinder and indicator cylinder to put the two in communication with each other at different points of expansion curve.

Mean-Pressure. The M.I.P.-Meter, J. Geiger. Oil Engine Power, vol. 4, no. 4, Apr. 1926, pp. 223–226, 15 figs. Details of mean-pressure indicator, for purpose of directly and continuously registering mean pressure within cylinders of reciprocating engines of all kinds at any instant; with assistance of curve thus registered, satisfactory recording of total power consumption is made possible; at same time practical means are afforded for seeing how load is distributed at any moment.

INDUSTRIAL MANAGEMENT

Budgeting. Forseeing Volume of Coming Orders, J. H. Barber. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 253–256, 2 figs. Author shows how to construct barometer curve from four groups of Federal Reserve statistics that indicate change in gross profit margins.

Estimates, Preparation of. The Use of Graphs in the Preparation of Estimates, E. G. Fiegehen. Mech. World, vol. 79, no. 2042, Feb. 19, 1926, pp. 146–147. Examples of uses to which estimating graphs may be put.

Financial and Industrial Investigations. Judging Operating Results, A. Andersen. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 277–280. Analysis of operating statements in financial and industrial investigation; determination of profits; importance of depreciation and appreciation; profit-and-loss statement; consideration of gross profits and costs.

Inventory Control. The Control of Inventory Through the Scientific Determination of Lot Sizes, H. S. Owen. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 257–260, 3 figs. Perpetual-inventory stock records.

Materials-Cost Standardization. Material Costs Can Be Standardized, F. H. Figsby. Factory, vol. 36, no. 3, Mar. 1926, pp. 431–432 and 586, 2 figs. It is found in actual practice that when raw-material costs are variable, standard costs offer special advantage because they quickly draw executive's attention to cost fluctuation that may make adjustments in selling price advisable.

Production Control. Maintaining Hourly Control of Production, G. G. Brooke. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 271–275, 7 figs. How E. G. Budd Mfg. Co., world's largest all-steel automobile body plant, regulates manufacturing operations.

Production Simplification. One-Day Production, E. Carlson. Factory, vol. 36, no. 3, Mar. 1926, pp. 433–435, 464, 466, 538, 540 and 542, 4 figs. How machine grouping, simplified layout, and conveyors have simplified production.

Project Engineers. Functions of a Project Engineer in a Technical Organization, J. F. Hardecker. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 641–642. Complete analysis made of system whereby one engineer follows through an assignment from preliminary design to finished product.

Purchasing. General Motors "Purchasing Power" Index, H. G. Weaver. Mfg. Industries, vol. 11, no. 4, Apr. 1926, pp. 291–292. Guide to marketing effort in different territories.

INDUSTRIAL PLANTS

Efficiency. Plant Efficiency. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 360–361. Problems affecting plant efficiency, including selections of site, plant design, site limitations affecting layout, etc., discussed at meeting of Am. Soc. Mech. Engrs.

Power-Costs Control. How Shall a Manager Control His Power Costs? W. H. Larkin, Jr. Factory, vol. 36, no. 3, Mar. 1926, pp. 444–445, 1 fig. Standard, monthly power report, as adopted by wide variety of industries, proves its case for simplicity and effectiveness; it is revolutionizing power costs in many plants.

INDUSTRIAL RELATIONS

Improving. Promoting Friendly Relations in Industry, E. M. Herr. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 621–622. Method as worked out at Westinghouse plant, East Pittsburgh, Pa.; distinction between owners and management in modern industrial undertakings; responsibilities of management of industrial enterprise.

Maintenance. Maintenance of Proper Relations Between Employer and Employee, E. M. Herr. West. Machy. World, vol. 17, no. 3, Mar. 1926, pp. 99–100 and 135. Discusses problems involved, comprising training, handling and disciplining of all employees in such manner as to keep them satisfied and to bring about most effective production relationship to industry; stresses importance of coöperation between employer and employees.

INSULATION, HEAT

High-Temperature. High Temperature Insulation, C. S. Gillette. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 1, Feb. 1926, pp. 3–16, 3 figs. Advantages of proper heat insulation if piping and machinery on shipboard.

INTERCHANGEABLE MANUFACTURE

Accuracy Control. Accuracy Control in Interchangeable Manufacture, C. O. Herb. Machy. (N. Y.), vol. 32, no. 9, May 1926, pp. 683–686, 6 figs. How White Motor Co. specifies limits on parts and gages from standardized lists and systematically inspects all gages.

INTERNAL-COMBUSTION ENGINES

Combustion. Control of Carburation in Explosion Engines by Exhaust-Gas Analysis and Carburation Curves (Contrôle de la carburation dans les moteurs à explosion par l'analyse des gaz d'échappement dans les moteurs explosion par l'analyse des gaz d'échappement et les diagrammes de carburation), B. Jousset. Chaleur et Industrie, vol. 7, no. 71, Mar. 1926, pp. 124–126, 1 fig. Shows how to determine ratio of air to fuel in engine by determining CO_2 contained in exhaust gas, considering theoretically perfect combustion, combustion with excess of air, and combustion with lack of air.

Cylinders. Thermal Stresses in Engine Cylinders, D. Laugharne-Thornton. World Power, vol. 5, no. 27, Mar. 1926, pp. 136–145, 5 figs. Examines principal factors to be considered in determination of stresses which arise in internal-combustion-engine cylinder as result of changes of temperature which such part is subject to during ordinary cycle of engine.

Instruments for. Instruments for Internal-Combustion Engines. Shipbldr., vol. 33, no. 187, Mar. 1926, pp. 150–151, 6 figs. Thermoelectric pyrometers for determining exhaust temperatures; instruments for obtaining accurate indicator diagrams.

Power Plants. The Internal Combustion Engine in the Power House, J. Richardson. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 81–84, 5 figs. Historical survey of development; chief type of engines at present in use.

Temperature Distribution and Heat Stresses. Temperature and Heat Stresses in Internal-Combustion Engines (Temperaturverlauf und Wärmespannungen in Verbrennungsmaschinen). Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 13, Mar. 27, 1926, pp. 429–436, 21 figs. Temperature distribution in cylinder walls; heat stresses when starting and during operation; temperature measurements on a Sulzer 2-stroke marine engine.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON ALLOYS

Iron-Chromium. The Nature of the Alloys of Iron and Chromium, E. C. Bain. Am. Soc. Steel Treating—Trans., vol. 9, no. 1, Jan. 1926, pp. 9–32, 18 figs. Development and preservation at room temperature of delta-iron solid solution; study covers range of alloys between pure and 30 per cent chromium; alloys containing more than 25 per cent chromium are without transformation; with this chromium content carbon in excess of 40 per cent is required to produce appreciable amount of austenite at any temperature; in alloys containing more than 10 per cent chromium, delta iron is produced in form sufficiently stable to be quenched unchanged to room temperature; carbon acts to increase solubility of chromium in gamma iron and to render it stable constituent in alloys containing more than 14 per cent chromium.

Iron-Silicon. Iron and Silicon. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 43–44, 1 fig. Review of work by Wever and Giani on investigation of iron-silicon alloys, account of which is published in Stahl u. Eisen, Jan. 14, 1926.

IRON AND STEEL

Warping. Why Metal Warps and Cracks, J. F. Keller. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 373–400 and (discussion) 400–402, 12 figs. Factors which come into play in causing iron and steel bodies to warp or crack when subjected to heat; illustrates by means of diagrams and experiments manner in which these factors cause failure of metallic bodies; photographs show effect of external strains.

IRON CASTINGS

Chilled. Making Chilled Castings in Jobbing Foundries, R. Coulthurst. Mech. World, vol. 79, no. 2047, Mar. 26, 1926, pp. 246–247. Discusses difficulties encountered by jobbing foundry, as follows: size of chill, nature of metal to be used, temperature of molten metal entering mold, chief differences in molding as against molds for ordinary castings, and depth of chill.

Methods and Processes. Comparisons in Foundry Methods and Processes, E. Longden. Foundry Trade Jl., vol. 33, no. 501, Mar. 25, 1926, pp. 227–232, 29 figs. Notes on oil-sand cores, wooden frames, molding tackle, gas-and-oil-engine pistons and liners; cupola design; solid and drop bottoms; special iron.

Notes on the Production of Castings. Foundry Trade Jl., vol. 33, no. 501, Mar. 25, 1926, p. 226. Cupola practice; sand problem; venting and cores; causes of defects. Abstract.

The Manufacture of Iron and Steel, F. T. Sisco. Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 305–322, 1 fig. Describes manufacture of iron and steel castings; method of preparing mold; various kinds of molds and their uses; iron for castings is melted in cupola using coke as fuel; various steel-making processes described insofar as they are used for production of steel for castings and their various advantages and disadvantages; preparing casting for shipment, digging out, cleaning, heat treatment and inspection.

Oxidizing. Oxidizing Cast Iron Castings, W. S. Barrows. Can. Foundryman, vol. 17, no. 3, Mar. 1926, p. 18. Term "oxidizing" includes practically all bronze finishes, employed for decorating and protecting products, which have previously received coating of copper or brass; causes of failure; oxidizing materials.

Sand Blasting. Sand Blasting and Other Aids to Fettling, F. W. Neville. Foundry Trade Jl., vol. 33, no. 497, Feb. 25, 1926, pp. 145–150, 8 figs. Discusses 3 systems of sand blasting in general use, pressure, suction and gravity feed; effect of various factors on working of plant, namely, relation between abrasion rate and flow rate, relation between flow rate and blasting efficiency, effect of air pressure on abrasion rate and blasting efficiency, life of abrasive, effect of wear on nozzles, finish obtained on cast-iron castings, etc.

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LATHES

Crankshaft. Wickes Semi-Automatic Crankshaft Lathes. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 663–664, 4 figs. Duplex and universal types of 34-in. lathe.

Flywheel-Turning. How Nash Flywheels are Made, F. Edwards. Western Machy. World, vol. 17, no. 3, Mar. 1926, pp. 101–103 and 131, 6 figs. Details of Simplimatic, simple automatic lathe for chucking and between-centers work made by Gisholt Machine Co.; how typical installations of these lathes has increased production and reduced cost of turning flywheels.

Tests. Investigation of Small Lathes as to Design, Construction and Efficiency (Untersuchungen an kleinen Drehbänken hinsichtlich Konstruktion, Ausführung und Leistung), F. Theimer. Zeit. Oesterr. Ingenieur- u. Architekten Vereines, vol. 78, no. 3–4, Jan. 22, 1926, pp. 23–26, 4 figs. Details of tests made by Vienna Technological Museum on large number of small lathes; mathematical checking of gears, feeds and speeds; accuracy of machine parts; efficiency and quality of work.

Turret. "Steel-Head" Flat Turret Lathes. Machy. (Lond.), vol. 27, no. 701, Mar. 4, 1926, pp. 741–742, 5 figs. New designs of Jones & Lanson Machine Co.

Vertical. Modern Vertical Boring and Turning Machine for Diameters of 8300 mm. and Heights of 3200 mm. (Neuzeitliches Karussel-Drehwerk für Arbeitsstücke bis 8300 mm. Durchmesser und 3200 mm. Höhe), Weil. Praktischer Maschinen-Konstrukteur, vol. 59, no. 1–2, Jan. 9, 1926, pp. 10–12, 7 figs. Machine constructed by Schiess A. G., Düsseldorf, for machining dynamo casings, rotors, flywheels, cylinders, turbine casing, etc.; driven by 75-hp. d.c. shunt motor at 300–900 r.p.m.

LIFTING JACKS

Hydraulic. Small Hydraulic Hoisting Apparatus (Hydraulische Klein-Hebewerkzeuge). Kruppsche Monatshefte, vol. 7, Feb. 1926, pp. 26–32, 14 figs. Various types of lifting jacks built by Krupps; their application, especially in machine shops.

LIFTING MAGNETS

Design. Lifting Magnets. Machy. (Lond.), vol. 27, no. 704, Mar. 25, 1926, pp. 833–835, 5 figs. Theory underlying design; weight of coil; cooling surface; points in construction of modern lifting magnets; control equipment.

LOCOMOTIVE BOILERS

Future Possibilities. Future Possibilities of the Locomotive Boiler, L. A. Rehfuss. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 212–214. Trend towards higher pressures; objections to water-tube boiler; objections to watering type of firebox; question of high steam temperatures.

Pitting. Great Northern Reduces Pitting of Locomotive Boilers. Ry. Age, vol. 80, no. 18, Apr. 3, 1926, pp. 951–958, 7 figs. Changes in water-treating methods yield striking results; mileage doubled and tube life trebled.

Repair Parts. Standardizing and Centralizing the Fabrication of Locomotive Boiler Repair Parts. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 71–77, 19 figs. Methods of laying out and fabricating boiler sheets and developing standard repair patches.

Water-Tube. McClellon Watertube Type Locomotive Boiler. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 65–70 and 82, 13 figs. Modifications made increase boiler pressure from 180 to 250 lbs., giving greater steam economy.

The Development of Watertube Locomotive Boilers L. A. Rehfuss. Boiler Maker, vol. 26, no. 3, Mar. 1926, pp. 83–86, 8 figs. Problems confronting designer of water-tube locomotive boilers and suggestions of possible trend in design.

LOCOMOTIVES

Automatic Stokers. Automatic Locomotive Firing (Ueber selbsttätige Lokomotivefeuerungen), Buhle. Wärme u. Kälte-Technik, vol. 28, no. 1, Jan. 1, 1926, pp. 2–4, 7 figs. Automatic stokers by Elvin Mechanical Stoker Co., Locomotive Stoker Co.; various types of locomotives, including Borsig and Krupp.

Central R. R. of New Jersey. Locomotive Development on the Central Railroad of New Jersey, P. T. Warner. Baldwin Locomotives, vol. 4, no. 4, Apr. 1926, pp. 8–23, 33 figs. Early motive power; review of developments.

Compound. High-Speed Compound Locomotives (Locomotive compound à grande vitesse), R. Vallantin. Revue Générale des Chemins de Fer, vol. 45, no. 2, Feb. 1926, pp. 89–100, 6 figs. Design and equipment of new locomotives, No. 241-A-1, with superheater, four-coupled wheels of 1.8-in. diameter, for Paris-Lyons railway; gave entire satisfaction after running 35,000 km.; comparison with Mikado and Pacific types.

Diesel-Electric. The Future of the Diesel-Electric Locomotive. Ry. Elec. Engr., vol. 17, no. 3, Mar. 1926, pp. 70–74, 2 figs. Discusses effect this type of motive power may have on heavy electric traction. Based on papers presented at meeting of New York sections of four founder engineering societies.

Economizer. Heat-Economic Development of Locomotive with Special Reference to Trial Trips of a

Locomotive Provided with Dabeg Economizer (Wärmewirtschaftliche Entwicklung der Lokomotive, unter besonderer Berücksichtigung von Versuchsfahrten einer mitt Dabeg-Vorwärmer ausgerüsteten Lokomotive), K. Fihak and Igel. Glasers Annalen, vol. 97, nos. 6 and 10, Sept. 15 and Nov. 15, 1925, pp. 112–119 and 188–193, and vol. 98, no. 5, Mar. 1, 1926, pp. 73–81, 13 figs. Discusses preheating of feedwater by flue gases; describes Dabeg pumps with injection preheater and their use on Austrian locomotives, including test runs made; calculation of water saved by Dabeg pump; test data with Dabeg preheater and with injector.

Eight-Coupled. Eight-Coupled Express Locomotives in France. Ry. Engr., vol. 47, no. 555, Apr. 1926, pp. 119 and 122, 2 figs. Comparative tests on 4-8-2 type, having 4-wheel front truck.

Electric. See ELECTRIC LOCOMOTIVES.

Garratt. The Garratt Locomotive, R. H. Whitelegg. Engineer, vol. 141, no. 3666, Apr. 2, 1926, p. 392. In development of Garratt engine, primary object was not provision of articulated engine as such, but construction of locomotive of high power, embodying boiler having dimensions beyond anything possible in normal rigid type of locomotive without exceeding weight per axle allowed by permanent way. (Abstract.) Paper read before North-East Coast Instn. Engrs. & Shipbldrs.

Headlights. Development of the Locomotive Headlight, J. H. Schroeder. Baldwin Locomotives, vol. 4, no. 4, Apr. 1926, pp. 25–28, 10 figs. Review of development; much success is due to special incandescent lamp now used, capable of standing severe vibration and all other railroad conditions.

High-Pressure. The Ultra-High-Pressure Locomotive. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 75–76, 1 fig. Ultra-high-pressure compound 3-cylinder 4-6-0 superheated-steam express engine for German state railways; developed by Schmidt Superheated Steam Co., Cassel-Wilhelmshohe, Germany.

Industrial Narrow-Gage. Industrial Locomotives (Baulokomotiven), Ewald. Hanomag Nachrichten, vol. 13, no. 147–148, Jan.-Feb. 1926, pp. 1–30, 50 figs. Narrow-gage locomotives from 50 to 280 hp. used for various industrial purposes for mining, canal and other construction work; choice of type for given work, choice of driving power; produced by Hanomag.

Internal-Combustion. Internal-Combustion Locomotives for Railway and Industrial Purposes. Ry. Gaz., vol. 44, no. 10, Mar. 5, 1926, pp. 324–325, 4 figs. Two useful types, manufactured by Crossley Bros., for switching about factory premises and yards.

Main-Rod Reclamation. Reclaiming Locomotive Main Rods, J. Murphy. Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 233–234, 4 figs. Rods weakened by repeated reaming operations are restored to original strength by thermit welding.

Mallet. Mallet Locomotives in Logging Service, A. J. Beuter and A. W. Kelly. Baldwin Locomotives, vol. 4, Apr. 1926, pp. 29–37, 18 figs. Review of development and latest types.

Oil-Electric. A Survey of Oil-Electric Locomotive Design, E. M. Speakman. Oil Engine Power, vol. 4, no. 4, Apr. 1926, pp. 210–214, 1 fig. Summary of weight and power data of major units built to date is basis of analytical commentary.

Switching. Eight-Wheel Switchers for the T. & P. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 901–903, 6 figs. With limited cut-off and 250-lb. boiler pressure, tractive force is 54,500 lb.; tender booster on two engines; constructed by Baldwin Locomotive Works. See also Ry. Mech. Engr., vol. 100, no. 4, Apr. 1926, pp. 216–219, 6 figs.

Three-Cylinder. The Three-Cylinder Locomotive. Ry. Age, vol. 80, no. 16, Mar. 20, 1926, pp. 849–850, 1 fig. Abstracts of papers read before Chicago Section of Am. Soc. Mech. Engrs., as follows: Construction and Economy Features, J. G. Blunt; Some Test Results, E. L. Woodward.

Three-Cylinder Locomotive for the Southern Pacific Ry. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 63–69, 13 figs. Details of construction, including boiler, flange lubricator, lateral-motion adjuster for driving boxes, booster cutout valve; eccentric crank and 6-wheeled tender truck.

Three-Cylinder Superheated Freight Locomotives for the Nigerian Railway. Ry. Engr., vol. 47, no. 555, Apr. 1926, pp. 136–137, 2 figs. General characteristics of these engines are such as to make another new standard for 3-ft. 6-in. gage.

Three-Cylinder Locomotives on the Wabash Railway, W. A. Pawnall. Ry. & Locomotive Eng., vol. 39, no. 3, Mar. 1926, pp. 81–84, 3 figs. Mikado-type freight locomotive built by American Locomotive Co.

2-10-2. Central of Georgia 2-10-2 Locomotives. Ry. Age, vol. 80, no. 16, Mar. 20, 1926, pp. 869–870. Develops 73,830-lb. tractive force with 190-lb. pressure, 30-in. by 32-in. cylinders and 63-in. driving sheels; built by Baldwin Locomotive Works, Phila.

Valve Gears. Testing Internal Valve Gear of a 3-Cylinder Freight Locomotive of the German Railway (Untersuchung der Innensteuerung der 1 E-Dreizylinder-Güterzung-Lokomotiven der Deutschen Reichsbahn), W. Lipperheide. Glasers Annalen, vol. 98, no. 4, Feb. 15, 1926, pp. 59–65, 18 figs. Shows defects of internal-valve-gear operation by means of new testing method; accurate curves show proper adjustment of slide valve, and whether, in repairing, proper dimensions have been adhered to.

LUBRICATING OILS

Purification. Oil Purification at Kearny Plant, D. F. Miller and R. H. Osgood. Elec. World, vol. 87, no. 16, Apr. 17, 1926, pp. 801–803, 3 figs. Systems for purifying turbine lubricating oil and transformer and circuit-breaker insulating oils at new generating station of Public Service Electric & Gas Co. at Kearny, N. J.

M

MACHINE SHOPS

Foundry. Equip Machines for Large Work, R. A. Fiske. Iron Age, vol. 117, no. 13, Apr. 1, 1926, pp. 899–902, 6 figs. New machine shop of Hubbard Steel Foundry Co., East Chicago, Ind., is located between two foundries; in this shop all castings, with the exception of rolls, are finished.

MACHINE TOOLS

Design Trends. Modern Aims and Tendencies in the Machine-Tool Industry (Neuzeitliche Aufgaben und Ziele des Werkzeugmaschinenbaues), Weil. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 13, Mar. 27, 1926, pp. 437–439. Points out that development of high-speed cutting steels (stellite, hardened steels) for obtaining higher working speed, opens up new problems for machine-tool builders necessitating radical changes in design; hints are given of future trends of design; importance of electrical engineering in machine-tool design; systematic coöperation between electrical engineer and machine-tool builder; problem of special types.

German Standards. Standards for German Machine Tools. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 638, 3 figs. Attempts have been made by German machine-tool builders to standardize direction of movement of all main movable parts of common types of machine tools and to eliminate all unusual motions therefrom.

Modern. Modern Machine Tools. Automobile Engr., vol. 16, no. 213, Mar. 1926, pp. 99–104, 7 figs. Special features that make for increased production; radial drilling machines; auxiliary high-speed spindle, tilting work tables; center lathes, variable speed headstock, capstan lathes and combination turret lathes; grinding, milling and boring machines.

Selection. How to Select Machine-Tools, W. G. Careins. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 275–278 and (discussion) 278–280. Analyzes concrete factors that should be given consideration in selection of machine equipment.

Small, Heavy Work on. Handling Heavy Work on Small Machines, J. H. Rodgers. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 632–633, 2 figs. Using rollers to support lathe work; extension plate for die-sinking machine; compensator for milling machine-table overhang.

MAGNESIUM

Properties. Magnesium and Its Alloys, S. L. Archbutt. Metallurgist (Supp. to Engineer, vol. 141, nos. 3657 and 3661), Jan. 29 and Feb. 26, 1926, pp. 4–6 and 26–30, 10 figs. Data in regard to mechanical properties in cast and wrought state; strength at high temperatures; in specific tenacity at high temperatures cast pure magnesium is shown to exhibit considerable superiority over cast iron.

MALLEABLE CASTINGS

Contraction. The Contraction of Malleable Castings, R. Stotz and F. Henfling. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 38–40, 2 figs. Consideration of shrinkage of white iron such as is used for production of malleable castings. Abstract translated from Stahl u. Eisen, Dec. 31, 1925. (See reference to original article in Eng. Index 1925, p. 465.)

MATERIALS HANDLING

Outside Haulage. Undeveloped Possibilities in Outside Haulage. Factory, vol. 36, no. 3, Mar. 1926, pp. 441–443, 510 and 514, 6 figs. Experiences of large steel mill with electric locomotives; of H. C. White Co. with gasoline locomotives; of Wilson Foundry & Machine Co., with tractor-trailers; and of Fedders Mfg. Co., with semi-trailers.

[See also ASH HANDLING; COAL HANDLING; FOUNDRIES; FREIGHT HANDLING.]

METAL SPRAYING

Application. Use of Metal Spraying Process in Transportation Industry (Die Verwendung des Metallspritzverfahrens im Verkehrswesen), G. Kutscher. Verkehrstechnik, no. 8, Feb. 19, 1926, pp. 123–128, 5 figs. Details of process; spray pistols; application to exterior and interior of boilers, etc.; extensive use for coating with zinc, also with preliminary aluminum coating.

METALS

Fatigue. On the Concentration of Stress in the Neighborhood of a Small Spherical Flaw; and on the Propagation of Fatigue Fracture in "Statistically Isotropic" Materials, R. V. Southwell and H. J. Gough. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. of Sci., vol. 1, no. 1, Jan. 1926, pp. 71–97, 12 figs. Concentration produced by small spherical flaw in material subjected to uniform tension; effect of small spherical flaw in twisted shaft; origin of fatigue fractures.

What Happens When Metal Fails by Fatigue? H. F. Moore. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 539–552, 4 figs. Presents picture of what happens when metal fails by fatigue under repeated stress; also pictures two actions going on in metal under repeated stress; one strengthening and the other destructive action; if destructive overbalances strengthening action, metal will fail.

Plastic Deformation. Plastic Formation (Plastische Gestaltung), P. Schweissguth. Maschinenbau, vol. 5, no. 3, Feb. 4, 1926, pp. 105–109, 6 figs. Discusses classification of plastic deformations: forging, rolling, cold drawing, and spraying; connection between rolling and forging, conception of plasticity, and of forging; kinds of forging and subdivisions.

Processes of Plastic Deformation (Ueber die Vorgänge bei der bildsamen Formänderung), H. Hoff and G. Sobbe. Maschinenbau, vol. 5, no. 3, Feb. 4, 1926, pp. 109–112, 16 figs. Discusses conception of plasticity, and reviews literature as to present knowledge regarding compression of plastic bodies and forms they assume in consequence.

The Mechanism of Plastic Deformation, Meyer and Nehl. Metallurgist (Supp. to Engineer, vol. 141, no. 3661), Feb. 26, 1926, pp. 23–25, 3 figs. Comprehensive résumé of existing theories, from critical study of which they have been able to advance explanation which appears to fit experimental facts, and which they support by results of numerous experiments. Abstract translated from Stahl u. Eisen, Nov. 1925.

Porosity. The Porosity of Metals. Metallurgist (Supp. to Engineer, vol. 141, no. 3665), Mar. 26, 1926, pp. 41–42. Results of experiments carried out by Tammann and Bredemeyer on such widely varied materials as copper, brass, steel and cast iron, showing that water, applied under pressure, penetrated to very considerable depth. (See reference to original article in Eng. Index 1925, p. 478, under METALS, Hollow Channels.)

Stress and Strain Hardness. The Mechanics of Metals (Vorbilder fur die Metallmechanik), F. Rinne. Zeit. für Metallkunde, vol. 18, nos. 2 and 3, Feb. and Mar. 1926, pp. 37–42 and 81–84, 34 figs. Discusses phenomena of stress, plastic deformation, strain hardness and fracture; author's optical and X-ray examinations are confined mainly to materials, such as rock salts, which are physically similar to metals, but possess advantage of being transparent and can therefore act as model; describes structural conditions of primary and secondary stress, whereby changing positions of and changes in atoms play important role; stresses due to isomorphous mixture; strain hardness is said to be due to coarsening of textures.

MILLING

Cam. Use of Dividing Head and Circular Attachment for Cam Milling. Machy. (Lond.), vol. 27, no. 702, Mar. 11, 1926, pp. 765–766, 2 figs. Index plate of dividing head should have proper number of holes to give angular divisions obtained by dividing total angles of cam rotation by number of cuts to be taken; tabulation of indexing of circular table or number of holes between cuts, etc., which should be furnished to machinist.

MILLING MACHINES

Double-Overarm. Double Overarm Milling Machine. Brit. Machine Tool Eng., vol. 3, no. 37, Jan.-Feb., 1926, pp. 369–370, 2 figs. Type of overarm employed on Parkinson machine consists of 2 cylindrical arms carried side by side so that centers of arms and centers of spindle form triangle.

Duplex. Full Automatic Table Control a Feature of New Milling Machine. Automotive Industries, vol. 54, no. 12, Mar. 25, 1926, pp. 538–540, 4 figs. Production miller brought out by Brown & Sharpe is of 2-spindle type; adapted for full automatic, part automatic and intermittent table operation; uses variety of fixtures.

High-Production Milling Machine. Iron Age, vol. 117, no. 12, Mar. 25, 1926, pp. 842–843, 3 figs. Full automatic table control is feature of new duplex machine, manufactured by Brown & Sharpe Mfg. Co., Providence; design permits use of wide variety of fixtures and attachments.

MOLDING MACHINES

Drive. Belt or Direct Electric Drive for Moulding Machines. Elec. News, vol. 35, no. 5, Mar. 1, 1926, pp. 49–51, 4 figs. Results of tests show startling reduction of costs with latter, accompanied by increased production.

MOLDING METHODS

Loam. Describe Loam Molding Methods, B. Shaw and J. Edgar. Foundry, vol. 54, nos. 5, 6 and 7, Mar. 1, 15, and Apr. 1, 1926, pp. 184–187, 225–228 and 275–279, 44 figs. Alternative method presented by which core is built directly in lower half of mold. Mar. 15: Various methods and devices adopted to make cores for irregular shapes. Apr. 1: Essential features of propeller-wheel mold.

Plate. The Latest Improvements of the Bonvillain Method for the Production of Cast Molding Plates (Die jüngsten Vervollkommungen des Bonvillainschen Verfahrens zur Herstellung gegossener Formplatten), C. Irresberger. Stahl u. Eisen, vol. 46, no. 12, Mar. 25, 1926, pp. 397–400, 14 figs. Discusses four main types of cast molding plates.

MOLDS

Formed with Cores. More Moulds Made with Cores, Caster. Metal Industry (Lond.), vol. 28, no. 10, Mar. 5, 1926, pp. 229–231, 10 figs. Supplement to series of article published in same journal in 1925, giving further interesting examples of construction of molds entirely or mainly from cores.

Gases from Molten Iron. Gases Evolved from Heated Iron, B. Hird. Foundry Trade Jl., vol. 33, no. 500, Mar. 18, 1926, pp. 219–221, 13 figs. Experiments to discover nature of gas which is given off from solid pieces of iron when their temperature is raised; this frequently occurs when nails, studs, chaplets, pieces of bar or pipe, chills or denseners are placed in molds and their temperature raised by pouring molten iron around them.

Permanent. Permanent Molds. Foundry Trade Jl., vol. 33, no. 497, Feb. 25, 1926, p. 156, 1 fig. New process of permanent mold cast-iron casting manufacture, consisting in provision of mold, facing of which consists of special refractory material which does not adhere to iron and strips so cleanly that beyond reblacking is suitable for recording and closing ready for reception of liquid metal.

Traces Steps in Long Life Mold Advance, H. Schwartz. Foundry, vol. 54, nos. 2, 3, 4 and 5, Jan. 15, Feb. 1, 15 and Mar. 1, 1926, pp. 42–44 and 76, 92–94, 147 and 149–150, and 189–192, 7 figs. Theory on which process is based, together with intimate details of construction and operation of molds. Feb. 1: Phases of mold deterioration; method of maintaining temperature of mold within certain predetermined temperature range. Feb. 15: Cooling velocity of permanent mold accelerated or retarded to secure hardness characteristics of castings. Mar. 1: Results obtained on batteries of permanent molds engaged in making automotive parts in modern production foundry.

Venting. Venting. Metal Industry (Lond.), vol. 28, no. 9, Feb. 26, 1926, pp. 205–206, 5 figs. Discusses dangers of misuse of vent wire, and points out how use of suitable facing sand and skill of molder will often avoid much artificial venting; describes job illustrating certain difficult problems in venting.

MOTOR BUSES

Brakes. Brakes for Heavy Vehicles, L. C. Huck. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 288–295 and (discussion) 295–298, 6 figs. Through mathematical analysis, author determines effect of self-actuation measured in terms of increase or decrease of cam pressure required to sustain same normal pressure before and after outside torque has been applied to brake drum; defines terms "actuation factor" and "actuation constant," and determines their values under different conditions; author concludes that in order that any braking system may operate efficiently, the linkage must be rigid and its geometry must be correct.

Design Changes. Motorcoach Builder's Attitude Toward Changes in Standard Designs, E. W. Templin. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 379–383, 1 fig. Consideration of requests which have been made for changes relating to type and make of headlights, clutch design, generator size and mounting, carburetor, lubricating system, steering columns speedometer, body parts.

Epicyclic Gears. Magnetically Controlled Epicyclic Gear. Motor Transport (Lond.), vol. 42, no. 1099, Mar. 22, 1926, pp. 349–350, 4 figs. Details of total transmission now being tested on Paris omnibuses as solution of driver problem.

Gasoline-Electric. An Electric Drive for Gasoline-Propelled Motorbuses. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 359–365. Discussion of paper by H. S. Baldwin, published in July 1925, issue of journal. See reference to original paper in Eng. Index 1925, p. 501.

Electrical Equipment for Gas-Electric Railless Vehicles, C. K. Lee. Elec. Jl., vol. 23, no. 3, Mar. 1926, pp. 136–142, 7 figs. Discusses different forms of gas-electric equipment on market; braking; series connection; operating results, and probable future.

New Fageol Gas-Electric Chassis Has Westinghouse Drive. Automotive Industries, vol. 54, no. 10, Mar. 11, 1926, pp. 440–441, 4 figs. Two electric motors and Hall-Scott six-cylinder engine form power plant; specially designed steel body used; maximum road speed, 35 m.p.h.

Operating Experience with Gasoline-Electric Motorcoaches. Soc. Automotive Engrs.—Jl., vol. 18, no. 4, Apr. 1926, pp. 373–377. Discussion of paper by R. H. Horton, published in Dec. 1925, issue of journal. See reference to original paper in Eng. Index 1925, p. 501.

Studebaker. A New Studebaker Saloon Coach. Motor Transport (Lond.), vol. 42, no. 1098, Mar. 15, 1926, pp. 237–329, 8 figs. Particulars regarding a six-cylinder medium-capacity vehicle with hydraulic 4-wheel brakes.

MOTOR-TRUCK TRANSPORTATION

Water-Terminal Operation and. Relation of the Motor Truck to Water Terminal Operation, W. F. Williams. World Ports, vol. 14, no. 5, Mar. 1926, pp. 49–54 and (discussion) 54–75. Discusses relation of motor vehicle to development of water-terminal business as applied in particular to Commonwealth Pier 5 in port of Boston.

MOTOR TRUCKS

Crossley-Kegresse. A Crossley-Kegresse 1-Tonner. Motor Transport (Lond.), vol. 42, no. 1097, Mar. 8, 1926, pp. 299–300, 4 figs. Recently introduced light chassis adopted for cross-country service; engine is of 4-cylinder monobloc type combined as one unit with single dry-plate clutch and right-hand controlled 4-speed gear box, whole flexibility supported at 3 points in frame.

German. German Motor Trucks (Nutzfahrzeuge), Automobil-Rundschau, vol. 28, no. 1, Jan. 1, 1926, pp. 5–10, 14 figs. Details of trucks at German automobile show; overhead camshafts seem to be giving place either to L-head or to overhead valves with push-rod drive; use of electron pistons in Magirus and Mannesmann-Mulag trucks; truck motor brake produced by Henschel u. Sohn, Kassel; solid-injection Diesel engine of M.A.N. works; trucks by Krupp, N.A.G., etc.

Lubrication. The Essentials of Industrial Truck and Tractor Lubrication, A. F. Brewer. Indus. Mgmt. (N. Y.), vol. 71, no. 4, Apr. 1926, pp. 247–252, 12 figs. Discusses lubrication requirements of chassis parts and final drives, etc., of various modern types of industrial tractors and trucks.

Operating Cost. Operating Costs and Economic Life of Motor Vehicles, W. H. Fairbanks. Soc. Automotive Engrs.—Jl., vol. 18, no. 3, Mar. 1926, pp. 285–287. Table summarizing operating costs of large mixed fleet for one year shows how records reveal highly important fundamental facts; relation of mileage to operating costs; methods of determining economic life of truck.

O

OIL ENGINES

Double-Acting. Double-Acting Engine of Wide Application. Oil Engine Power, vol. 4, no. 4, Apr. 1926, p. 215, 1 fig. Type now nearing completion at New London is 2-cylce design consisting of massive bedplate with cast-iron columns, guides, slippers, etc., in accordance with modern marine practice.

High-Efficiency. The High Efficiency Oil-Engine, A. E. L. Chorlton. Engineering, vol. 121, no. 3143, Mar. 26, 1926, pp. 409–411, 9 figs.; also Engineer, vol. 141, nos. 3665 and 3666, Mar. 26 and Apr. 2, 1926, pp. 364–366 and 394–395, 9 figs. Points out that main line of development has always been by increase of compression or expansion ratio, and suggests that it is in this direction that further progress is still possible; mechanical losses in internal-combustion engines; effect of speed on thermal efficiency; atomization; brief description of quick-running engine manufactured by Wm. Beardmore & Co. (Abstract.) Paper read before Instn. Mech. Engrs.

Junkers Opposed-Piston. The New Junkers Two-Stroke Engine (Der neue Doppelkolben-Zweitaktmotor von Professor Junkers), Schmolke. Wärme, vol. 49, no. 2, Jan. 8, 1926, p. 29, 1 fig. Engine is of opposed-piston type, with solid injection of oil through one or more nozzles when pistons are on their inner dead centers and space between them is filled with highly compressed air; shortly before outer dead centers are reached, exhaust and scavenging ports are opened; smooth surface of cylindrical space between pistons results in thorough scavenging and minimum transfe of heat before commencement of working stroke; use of opposed pistons facilitates balancing of engine; fuel consumption in larger engines is said to be only 0.35 lb. per b.hp. per hr.

M.A.N. The M.A.N. Double-Acting Marine Oil Engine. Engineer, vol. 141, nos. 3665 and 3666, Mar. 26 and Apr. 2, 1926, pp. 352–354 and 356, and 382–384. 9 figs. New engine operates on 2-cycle principle, with port scavenging, and is designed to develop 4400 b.hp. in 6 cylinders, when running at comparatively low speed of 84 r.p.m.; results obtained during recent tests; future development of this new type.

Mirrlees-Nobel. A Mirrlees-Nobel Marine Heavy-Oil Engine of 1000 B.H.P., Mar. Engr. & Motorship Bldr., vol. 49, no. 583, Mar. 1926, pp. 104–105, 1 fig. 4-cylinder, 2-stroke-cycle engine, designed to produce 1000 b.hp. at 125 r.p.m.

OIL FUEL

Combustion. Experience with the Combustion of Fuel Oil in Power Plant Boilers, J. F. Barkley. U. S. Bur. of Mines—Reports of Investigations, no. 2730, Feb. 1926, 6 pp., 1 fig. Also Oil & Gas Jl., vol. 24, no. 44, Mar. 25, 1926, pp. 90 and 92. Results of studies and tests made of various oil-burning equipments under power-plant boilers.

Specific Gravity and Viscosity. The Graphic Relation of Specific Gravity to Viscosity in the Case of Fuel Oils, G. B. Vroom. Am. Soc. Naval Engrs.—Jl., vol. 38, no. 1, Feb. 1926, pp. 119–129, 5 figs. Shows how, specific gravity and viscosity at known temperatures being given, its viscosity at any other temperature may be predicted within sufficiently accurate limits for practical working purposes.

OPTICAL INSTRUMENTS

Gaging Devices. New Projection Device for Testing Fine Bores (Neuartiger Projektionsspparat zum Prüfen feiner Bohrungen), O. Lich. Praktischer Maschinen-Konstrukteur, vol. 59, no. 5–6, Feb. 6, 1926, pp. 57–58, 6 figs. Device by Zeiss in Jena for testing roundness and proper dimensions to an accuracy of 0.00025 mm. or more.

Tooling Work. Accurate Angles by Optical Methods, F. C. Hudson. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 601–602, 4 figs. Simple and very accurate method of setting work at right angles, that can be used on any toolroom job.

Zeiss Measuring Machine. Zeiss Measuring Machine. Machy. (Lond.), vol. 27, no. 703, Mar. 18, 1926, pp. 815–816, 5 figs. Details of design; principle of optical system.

OXYACETYLENE WELDING

Applications. Oxygen the Wonder Worker, H. L. Rogers. Southern & Southwestern Ry. Club—Proc., vol. 18, no. 7, Jan. 1926, pp. 10, 13, 14, 17, 18, 21, 22 and 25 and (discussion) 25, 26, 29, 30, 33, and 34. Oxyacetylene welding torch and principle; oxyacetylene cutting torch; welders and cutters; application to railway work.

Cast-Iron Heater Sections. Procedure Control for Oxyacetylene Welding Cast Iron Heater Sections, J. W. Haygood. Am. Welding Soc.—Jl., vol. 5, no. 2, Feb. 1926, pp. 7–11. Selection and inspection of material; design and layout of welded joint; preparation of piece for welding; welding technique; inspection and test.

Copper. Oxy-Acetylene Welding of Copper, S. W. Miller. Am. Mach., vol. 64, no. 16, Apr. 22, 1926, pp. 639–640, 4 figs. Introduction of silicon as deoxidizer in metal being welded as well as in welding rod results in production of sound welds.

P

PARACHUTES

Civilian and Airship. Civilian and Airship Parachutes, H. S. Holt. Aeroplane, vol. 30, no. 12, Mar. 24, 1926, pp. 316, 318 and 320, 5 figs. Discusses problems for passengers not exceeding four on open machines, and for passengers on large air liners with covered-in saloons.

PIPE, CAST-IRON

Bronze Welding. Bronze Welding of Cast Iron Pipe, H. Y. Carson. Acetylene Jl., vol. 27, no. 9, Mar. 1926, pp. 429–435, 9 figs. Results of tests; practical bronze-welding data. Paper presented before Gas Products Assn.

Centrifugally Cast. Centrifugally-Cast Pipes at the Works of the Stanton Ironworks Company, Limited. Iron & Coal Trades Rev., vol. 112, no. 3029, Mar. 19, 1926, pp. 479–482, 13 figs. Methods and equipment of plant installed at Stanton Works near Nottingham, Eng., employing de Lavaud process.

Corrosion. Factors Other Than Dissolved Oxygen Influencing the Corrosion of Iron Pipes, J. R. Baylis. Indus. & Eng. Chem., vol. 18, no. 4, Apr. 1926, pp. 370–380, 13 figs. Investigation, which has been under way for several years, covering several phases of problem; electrochemical theory of corrosion; solubility of ferrous hydroxide and of ferrous carbonate; compounds formed in corrosion of iron; examination of question as to whether ferrous hydroxide precipitates during corrosion; influence of negative ions; pitting and tuberculation.

PISTONS

Aluminum. Aluminum Pistons (Der Aluminiumkolben im Fahrzeugmotor), C. Steiner. Motorwagen, vol. 29, nos. 1 and 3, Jan. 10 and 31, 1926, pp. 8–9 and 52–55, 16 figs. Author is of opinion that it is difficult to avoid play of piston pins in piston bosses since aluminum expands so much more than steel; he therefore recommends floating pins so proportioned that bearing pressure in bosses will not exceed 2500 lb. per sq. in. when explosion pressure is 450 lb.; a good thing is to cast steel bushings into bosses; stress of 15,000 to 18,000 lb. per sq. in. is permissible in bending for good fine-grained cast iron for rings. Comparison of efficiency and fuel consumption with aluminum and with gray-cast-iron pistons.

Manufacture. Piston Methods, F. H. Colvin. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 581–583, 14 figs. Methods and sequence of operations and devices used; burnishing ring grooves, grinding relief and facing pistons to length.

PLANERS

Testing Gears. Testing Planer Gears, C. E. Linden. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, p. 650, 3 figs. Use of special testing fixture may be employed with all large spur, helical, or herringbone gears.

PLATES

Flat Circular, Vibrations in. The Frequencies of Vibration of Flat Circular Plates fixed at the Circumference, H. Carrington. Lond., Edinburgh, & Dublin Philosophical Mag. & Jl. of Sci., vol. 50, no. 300, Dec. 1925, pp. 1261–1264. Gives equations and tables for frequencies of transverse symmetrical vibration of fixed circular plate.

Rectangular, Calculation of. Calculating Flat Rectangular Plates (Calcul des plaques rectangulaires planes), R. Lemaitre. Revue Universelle des Mines, vol. 9, no. 2, Jan. 15, 1926, pp. 58–80, 6 figs. Calculation of plates supported at their circumference and subjected to uniform load per unit.

Ripping up, Machine for. A Large Plate Ripping Machine. Engineer, vol. 141, no. 3664, Mar. 19, 1926, p. 333, 9 figs. partly on pp. 326 and 332. Machine employed for ripping up steel plates required for construction of Sydney Harbor bridge; it can accommodate plates up to 5 ft. in width and 67 ft. in length, and is capable of ripping them from end to end.

POWER

Purchased vs. Generated. Whether to Buy Power or Make I, J. Breslove. Iron Age, vol. 117, no. 18, May 6, 1926, pp. 1259–1263, 6 figs. Question of buying power or making it revolves around internal conditions in each plant; when steam is required for process work or other special conditions prevail, actual cost of power itself becomes of secondary importance; author discusses these points and tells how one plant attacked problem and found its solution.

PULVERIZED COAL

Gyro Gasification Systems. Installations of a New Pulverized Fuel System, E. K. Scott. Combustion, vol. 14, no. 4, Apr. 1926, pp. 250–253, 3 figs. Firing equipment installed on Gyro gasification system at power stations of West Ham Corp. and Dover Corp.

Limitations and Comparisons. Some Limitations and Comparisons, E. W. L. Nicol. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 57–61, 3 figs. Discusses whole question of advantages from an impartial standpoint, and explains systems at present in operation.

PUMPING STATIONS

Design Problem. Pumps, Power and Stations, R. W. Angus. Can. Engr., vol. 50, no. 10, Mar. 9, 1926, pp. 51–52 and (discussion) 53–54, 4 figs. Vertical triple-expansion engines; centrifugal and single-stage pumps; high-speed low-head pump; steam turbines and electric motors; standby units. Paper read before Can. Section, Am. Water Wks. Assn.

Power Generation for. Steam, Oil and Electric Power, E. A. Allcut. Can. Engr., vol. 50, no. 10, Mar. 9, 1926, pp. 54–56. Review of present practice and possible future developments in generation of power for pumping plants.

PUMPS

Air-Lift. Air Lift Pumps (Druckluft Wasserheber), F. Dabrowski. Zeit. des Oberschlesischen Berg- u. Hüttenmännischen Vereins Zu Katowice, vol. 65, no. 1, Jan. 1926, pp. 13–24, 9 figs. Describes "Mammut"

pump used in mining, operation and calculation of performances; amount of air consumed per unit of volume, initial and final velocity of flow; comparison of Borsig and Sullivan systems.

PUMPS, CENTRIFUGAL

Automatic Control. A Few New Minor Changes Improve Automatic Pumping Service, E. J. Gealy. Coal Age, vol. 29, no. 9, Mar. 4, 1926, pp. 323–324, 3 figs. Details of improvements which have simplified and perfected operation of original automatic features.

Recent Improvements in Automatic Centrifugal Pump Control Simplify Apparatus, R. S. Sage. Coal Age, vol. 29, no. 9, Mar. 4, 1926, pp. 321–322, 1 fig. Time-delay relay takes place of notching type; adjustments are made to suit pumping conditions; in case of trouble pump is locked out of service.

Impellers, Water-Pressure Distribution in. Experimental Research on the Distribution of Water Pressure in a Centrifugal Pump Impeller, S. Uchimaru. Faculty of Eng., Tokoyo Imperial Univ.—Jl., vol. 16, no. 6, Sept. 1925, pp. 157–169, 65 figs. partly on supp. plates. Result of experiment to determine variation of water pressure at different points in impeller channel when rotating and delivering water.

R

RADIATION

Direct. Heat Emission, Heating Effect and Heating Efficiency of Direct Radiation, K. Meier. Am. Soc. of Heat. and Vent. Engrs.—Jl., vol. 32, no. 3, Mar. 1926, pp. 159–163. Heat emission as found by condensation and expressed in B.t.u. represents capacity of radiator under stated working conditions; heating effect is a quality more or less variable; heating efficiency is degree of utilization which may be stated in percentages; as generally understood it is ratio between heat actually utilized and that contained in fuel.

RAILS

Detecting Defects in. Track Device for Detecting Defects in Rails, M. Suzuky. Eng. News-Rec., vol. 96, no. 13, Apr. 1, 1926, pp. 520–522, 4 figs. To detect and locate in rails in track such internal defects as transverse fissures, spots affected by abnormal stresses and segregation of impurities, portable magnetic apparatus has been devised by Japanese engineers, which utilizes magnetic induction by leakage magnetic-flux method and is known as defectoscope.

RAILWAY ELECTRIFICATION

Chicago. Chicago Terminal Electrification on the Illinois Central, D. J. Brumley. Eng. News-Rec., vol. 96, no. 8, Feb. 25, 1926, pp. 322–326, 3 figs. Terminal and lake-front improvements; passenger stations and freight yard; overhead wire system; suburban-train equipment.

RAILWAY MANAGEMENT

Stores Department. Delaware & Hudson Has Well Equipped Store Department. Ry. Age, vol. 80, no. 19, Apr. 10, 1926, pp. 1015–1018, 6 figs. Radial scrap dock cuts sorting costs to new low record of 34 cents a ton; gantries for lumber handling.

RAILWAY MOTOR CARS

Benzol. Railway Motor Cars for Freight Traffic (Benzoltriebwagen für Güterverkehr), E. Heintz. Fördertechnik u. Frachtverkehr, vol. 19, no. 6, Mar. 19, 1926, pp. 77–80, 5 figs. Efforts of Daimler, Deutsche Werke, and A. E. G. to produce satisfactory car and gearing for a speed of 35 kw-hr.

Gasoline-Electric. A 73-Foot Gas Electric Car for Boston and Maine. Ry. Elec. Engr., vol. 17, no. 4, Apr. 1926, pp. 109–110, 4 figs. Control circuits and 760-watt lighting load supplied by 215 ampere-hour battery and 2.5-kw. exciter.

Large Gas-Electric Car for the Boston & Maine, T. H. Murphy. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 911–913, 4 figs. Car which is 73 ft. long and seats 92 passengers will meet service requirements without trailer.

Germany. A new Gasoline Motor Car of the German Railway (Ein neuer Benzin-Triebwagen der Deutschen Reichsbahn-Gesellschaft), P. Friedmann. Verkehrstechnik, vol. 43, no. 12, Mar. 19, 1926, pp. 192–195, 5 figs. Car built by Waggon & Maschinenbau A. G. at Görlitz, with six-cylinder Büssing engine developing 90 hp. at 1000 r.p.m. and automatic speed-change mechanism and reversing gear.

A Year's Operating Experience with Railway Motor Cars on the Südstormarn Line (Ein Jahr Triebwagenbetrieb auf der Südstormarnschen Kreisbahn), R. Sieber. Verkehrstechnik, vol. 43, no. 11, Mar. 12, 1926, pp. 173–176, 3 figs. Experience with gasoline-driven car shows that, compared with steam, its cost was 91 per cent with trailer and 72 per cent without trailer, but that with 100 kg. gasoline equal in price to 2500 kg. rich coal, costs are equal.

Maintenance. Methods of Maintaining Motor Cars. Ry. Rev., vol. 78, no. 11, Mar. 13, 1926, pp. 514–519, 2 figs. Abstract. Report of subcommittee of Committee of Economics of Railway Labor, Am. Ry. Eng. Assn.

Mechanical Transmission. Smalley Rail Car Mechanically Driven Through Herringbone Gears, P. M. Heldt. Automotive Industries, vol. 54, no. 13, Apr. 1, 1926, pp. 566–567, 3 figs. Powered by 2 Climax 4-cylinder engines which develop 76 hp. at 1200 r.p.m.; gear changes effected with Campbell sliding-key arrangement; radiator fan driven by spur gears.

RAILWAY OPERATION

A.R.E.A. Report. Report of Committee XXI—Economics of Railway Operation. Am. Ry. Eng. Assn.—Bul., vol. 27, no. 284, Feb. 1926, pp. 733–757, 15 figs. Effect of speed of trains upon cost of transporting freight; method of increasing traffic capacity of railway; effect of installing automatic signals. See also (abstract) in Ry. Age, vol. 80, no. 14, Mar. 12, 1926, pp. 760–764.

Train Control. Train Control Devices Approved. Ry. Age, vol. 80, no. 17, Mar. 27, 1926, pp. 908–910. Interstate Commerce Commission approved 2-speed continuous-induction train-control system of Union Switch & Signal Co., as installed on Wyoming division of Union Pac. and also approved with certain exceptions automatic train-stop system of Nat. Safety Appliance Co. on Central Kansas Division of Missouri Pac.

Train Control Instruction and Inspection. Ry. Elec. Engr., vol. 17, no. 4, Apr. 1926, pp. 122–123, 4 figs. Tracks employed in maintenance program of Richmond, Fredericksburg and Potomac.

RAILWAY REPAIR SHOPS

Driving-Box Repairs. Driving Box Practice at the C. & N. W. Shops, F. W. Curtis. Am. Mach., vol. 64, no. 13, Apr. 1, 1926, pp. 501–504, 11 figs. Methods of special details for driving-box repairs employed in Chicago shops.

Equipment. How Railroad Repair Shops Are Equipped. Am. Mach., vol. 64, no. 15, Apr. 15, 1926, pp. 586–587, 2 figs. Statistical analysis of types of equipment and their relative ages.

Locomotive. Handling Locomotive Repairs to Meet a Scheduling System, F. W. Curtis. Am. Mach., vol. 64, no. 11, Mar. 18, 1926, pp. 433–436, 12 figs. Methods employed at Silvis Shops of Chicago, Rock Island & Pac. Ry.

Santa Fe Completes Reconstruction of Coast Line Shops. Ry. Age, vol. 80, no. 19, Apr. 10, 1926, pp. 1001–1009, 14 figs. Locomotive repair plant at San Bernardino is rebuilt on enlarged scale and fully equipped with latest labor-saving machinery.

Passenger-Car. General Layout and Design of Passenger Car Shops. Ry. Rev., vol. 78, no. 11, Mar. 13, 1926, pp. 508–513, 4 figs. Abstract. Report of subcommittee of shops and locomotive terminals, Am. Ry. Eng. Assn.

RAILWAY SIGNALING

Color-Light Signals. Color-Light and A. C. Floating Change-Over on the Burlington. Ry. Signaling, vol. 19, no. 4, Apr. 1926, pp. 152–154, 4 figs. Primary batteries and lower quadrant double-arm semaphore signals removed between Chicago and Aurora.

Four-Aspect Colour Light and Power Signaling Southern Railway. Ry. Gaz., vol. 44, no. 13, Mar. 26, 1926, pp. 456–461, 11 figs. Describes how system, in association with electric power signaling, has been practically applied.

Four-Aspect Colour Light Signals. Ry. Gaz., vol. 44, no. 11, Mar. 12, 1926, pp. 359–361, 1 fig. Application to Southern Railway (England) suburban routes.

RAILWAY SWITCHES

Car Retarders. Electro-Pneumatic Car Retarders in Service on Illinois Central. Ry. Signaling, vol. 19, no. 4, Apr. 1926, pp. 137–141, 11 figs. Installation of Union Switch & Signal Co., equipment on northbound classification yard at Markham largest in world.

REFRIGERATING MACHINES

Domestic. Efficiency Test of Domestic Refrigerators. Ice & Refrigeration, vol. 70, no. 3, Mar. 1926, pp. 305–310, 12 figs. Results of series of tests conducted at laboratories of Armour Institute of Technology, Chicago, in which 10 refrigerators were used, all identical in shape, size and workmanship with exception of heat-insulating material used in walls.

REFRIGERATING PLANTS

Brine Handling in Coolers. Handling Brine in Coolers and Spray Systems, J. F. Staley. Power Plant Eng., vol. 30, no. 7, Apr. 1, 1926, pp. 440–442, 2 figs. Discusses operation of coolers for both salt and calcium brine, layout of brine spray system and design of brine evaporator.

S

SCREW MACHINES

End-Knurling Tools for. End-Knurling Tools for Screw Machine, H. Simon. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 609–612, 5 figs. Problems involved in designing tool equipment; making knurls; developing knurl-roll holder; preparing work for knurling.

SCREW THREADS

Tangential Cutting. Thread Cutting by Means of Tangential Detachment of Chips With Rotating Self-Opening Screwing Chucks (Das Schneiden von Gewinden durch tangentiale Spanabhebung mittels umlaufenden, selbstöffnenden Schneidkopfes), R. Meininger. Maschinenbau, vol. 5, no. 4, Feb. 18, 1926, pp. 167–170, 15 figs. Differences in principles of radial and tangential cutting; radial and tangential cutting heads; thread cutting with various pitches; left-handed threads.

SEAPLANES

De Havilland. Seaplane for G. G. of Australia. Flight, vol. 18, no. 13, Apr. 1, 1926, pp. 188–190, 4 figs. D.H. 50 has been fitted with duralumin floats built at works of Short Bros., Rochester, Eng.

Large. Recent Experiments with Large Seaplanes, A. Rohrbach. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 353, Mar. 1926, 33 pp., 15 figs. on supp. plate. Account of what has been accomplished in author's companies, demonstrating correctness of his views of increasing size of airplanes; advantages of heavy wing load; wing structure; maximum strength with minimum weight; safety in event of injury of important parts; easy accessibility of every structural part; inexpensive manufacture. Translated from Berichte und Abhandlungen der Wissenschaftlichen Gesellschaft für Luftfahrt.

Short Mussel. The Short S. 7 Mussel. Flight, vol. 18, no. 10, Mar. 11, 1926, pp. 141–145, 15 figs. Designed for use as light training machine; seaplane which can be turned into landplane by substituting wheel under carriage and tail skid for twin-float undercarriage; equipped with A.D.C. Cirrus 4-cylinder air-cooled engine. See also Aeroplane, vol. 30, no. 10, Mar. 10, 1926, pp. 266–267, 2 figs.

SHAFTS

Vibrations. Graphical Method of Determining Torsional Vibrations in Shafts (Zeichnerisches Verfahren zur Bestimmung der Torsions-Eigenschwingungszahlen von Wellen), P. Kohn. Maschinenbau, vol. 5, no. 5, Mar. 4, 1926, pp. 220–221, 3 figs. Method for determining torsional period of vibrations which is comparatively simple.

STANDARDIZATION

Germany. German Standardization Work (Die deutschen Normungsarbeiten), F. Neuhaus. Technik u. Wirtschaft, vol. 19, no. 1, Jan. 1926, pp. 31–34, 4 figs. Development of German Industrial Standards Committee (N. D. I.) and its work of standardizing and reduction of types; difficulties in adoption of standards; specialization by firms in standard articles, etc.

Variety Through. Variety Through Standardization, C. E. Skinner. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 327–329. Nature's use of standards; electrical industry as illustration of value of standardization; work already done in industrial standardization; work of Am. Eng. Standards Committee in national and international standardization; scope of and necessary limitations.

STEAM

High-Pressure. High-Pressure Steam in Industrial Plants, A. F. Sheehan. Power, vol. 63, no. 16, Apr. 20, 1926, p. 606. Advantages when process steam is needed; higher installation costs.

STEAM ENGINES

Corliss. Largest Corliss Engine in Twenty Years. Power, vol. 63, no. 12, Mar. 23, 1926, pp. 441–442, 4 figs. Twin tandem engine capable of developing maximum of 15,000 hp. at 200-lb. steam pressure is being installed for rope drive at one of large steel mills.

High-Pressure. A High-Pressure Quadruple-Expansion Engine. Shipbldg. & Shipg. Rec., vol. 27, no. 11, Mar. 18, 1926, pp. 328 and 335. Details of new set of engines and boilers, intended for propulsion of 11-knot cargo steamer, built by Central Marine Engine Wks.

STEAM PIPE

Cost Estimation. Estimating Fabricated Pipe Costs, I. A. Butcher. Power, vol. 63, nos. 11 and 12, Mar. 16 and 23, 1926, pp. 414–416 and 443–445, 8 figs. Method by which it should be possible for engineer to estimate power-plant piping. Mar. 16: Compares cost of gas-welded pipe work with fitting job. Mar. 23: Cost of cutting and threading operations, pipe joints, pipe bending, etc.

STEAM POWER PLANTS

Combined Heating and Generating. Combination Power and Heating Plants in North Bohemia, J. H. D. Blanke. Nat. Engr., vol. 30, no. 3, Mar. 1926, pp. 97–101, 4 figs. Review of recent developments in this field in Germany and Czechoslovakia; problems of exhaust-steam utilization and coöperation with central-station power systems worked out; translated from Zeit. des Vereines deutscher Ingenieure, June 27, 1925.

Cost Analysis. Power Plant Costing, C. H. S. Tupholme. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 48–51, 3 figs. How various costs incurred in factory power house should be allocated in works account system.

Production Cost in Private Plant Operation, E. Winholt. Nat. Engr., vol. 30, no. 3, Mar. 1926, pp. 95–96. Practical illustration of cost analysis and factors chargeable to cost of service.

Design. Designing a 500-Horsepower Steam Power Plant, C. L. Hubbard. Southern Power Jl., vol. 44, no. 3, Mar. 1926, pp. 50–55, 8 figs. Making preliminary layout of plant, showing space required and general arrangement of building in its different parts.

Operation. The Economical Operation of the Power Plant, W. D. Wylde. Indus. Mgmt. (Lond.), (Cassier's Works Power No.), vol. 13, no. 2, Feb. 1926, pp. 39–48, 15 figs. Exhaustive survey of appliances and names available by which economics may be effected in power house, and whereby high state of efficiency can be obtained and maintained continuously throughout production and utilization of power irrespective of type or size of plant concerned.

Piping. Industrial Power Plant Piping, T. Maynz. Chem. and Met. Eng., vol. 33, no. 4, Apr. 1926, pp. 229–230. Design and upkeep of pipe lines for water, steam and air with reference to expansion, heat losses and other important factors.

Western Electric Co., Kearny, N. J. Western Electric Co.'s Power Plant at New Kearny Works. Power, vol. 14, Apr. 6, 1926, pp. 514–518, 8 figs.

Plant designed for 20,000-kw. generating capacity; condensing, non-condensing and mixed-pressure turbines used; forced hot-water circulation for heating all buildings; small-sized anthracite used as fuel.

STEAM TURBINES

Back-Pressure. Tests of Back-Pressure Steam Turbine and Reaction Blades (L'amélioration du rendement de l'ailettage à réaction à vapeur), M. Hentsch. Génie Civil, vol. 88, no. 10, Mar. 6, 1926, pp. 228–230; also translated abstract in Engineer, vol. 141, no. 3669, Apr. 23, 1926, p. 462. Results of test carried out by Stodola on Brown-Boveri turbine having rated capacity of 1000 kw. at 3000 r.p.m.; reaction blades are of brass with thinned tips; data on efficiency of reaction blading and of complete turbine.

Bleeding. Bled Steam Heating, D. T. McHutchison. Mech. World, vol. 79, no. 2044, Mar. 5, 1926, pp. 187–188, 2 figs. Economy resulting from practice is due to fact that steam used for heating has already done considerable amount of useful work in main turbine; this is obviously more efficient than using high-pressure steam, and also more economical than putting in steam-driven auxiliaries in order to obtain supply of exhaust steam for purpose.

Developments. Modern Development of Steam Turbine Design, E. A. Kraft. Eng. Progress, vol. 7, no. 3, Mar. 1926, pp. 61–63, 5 figs. Examples of recent types.

Exhaust Pressure. Turbine Exhaust Pressure Measurement, W. A. Carter. Power, vol. 63, no. 13, Mar. 30, 1926, p. 488, 3 figs. Results of tests indicate that A.S.M.E. test-code method for measuring exhaust pressure is preferable to either British tip or square-wire gauze tip.

Extraction. Extracted Steam Solves Power Problem. Power, vol. 63, no. 13, Mar. 30, 1926, pp. 474–477, 8 figs. Proximity Mfg. Co., denim cloth manufacturer, makes remarkable power cost reduction by installing extraction turbine and high-pressure boilers; steam at 15 lb. bled to supply dye house; boilers operate at 200 lb. and with 100-deg. superheat.

Van den Bossche. The Van Den Bossche Turbine (La Turbine van den Bossche), J. van den Bossche. Chaleur et Industrie, vol. 7, no. 70, Feb. 1926, pp. 77–79, 4 figs. Calculation of turbine based on principle that it is possible to convert total heat of steam in permanent motion into exterior work, and that it is impossible to use integrally kinetic energy of steam in motion in turbine without modifying its thermodynamic state.

STEEL

Air Cooling. Observations on Temperature Distribution in Steel Bodies Cooled in Air, E. J. Janitzky. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 452–457, 2 figs. Method of approximating temperature drops at any instant and at any distance from center in steel bodies cooled in air to ordinary atmospheric temperature, when total time to reach coolant temperature and exponent of center curve equations are given.

Boiler-Furnace. Furnace Steels. Eng. & Boiler House Rev., vol. 39, no. 9, Mar. 1926, pp. 430–433, 434, 437 and 438, 3 figs. Results of recent research work carried out by the firm of Hadfields, Ltd., Sheffield, England.

Chromium. See CHROMIUM STEEL.

Failures. Facts and Principles Concerning Steel and Heat Treatment, H. B. Knowlton. Am. Soc. Steel Treating—Trans., vol. 9, no. 4, Apr. 1926, pp. 615–636, 7 figs. Deals with mechanism of steel failures, discusses composition of matter, and structure and properties of crystals appearing in steel and iron; stresses which cause failure and internal effects they produce in metal under stress; application of fundamental principles to practical problems in prevention of cracking and breaking.

Martensitic Structure. On Martensite, H. Hanemann and A. Schrader. Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 169–233 and (discussion) 233–239 and 364, 72 figs. Review of previous investigations on structure of martensite and austenite in hardened steels; authors point out that established facts of austenite-martensite reaction cannot be reconciled with alpha-iron hypothesis and give their investigations of new hypothesis of martensite formation called epsilon-eta hypothesis. Includes decription of 71 photomicrographs. Bibliography.

Pearlite Interval. The Effect of Manganese, Silicon and Phosphorus on the Pearlite Interval, B. Kjerrman. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 430–451, 15 figs. Effect of these elements upon this range is experimentally determined by change in electrical resistance on heating; manganese lowers range, silicon raises it; steel sufficiently high in both manganese and silicon shows two separate ranges as determined by resistance method.

Sheet. Sheet Steel—Specification and Inspection, L. N. Brown. Forging—Stamping—Heat Treating, vol. 12, no. 3, Mar. 1926, pp. 84–90. Improved methods of testing; inspecting "seconds;" finishes for automotive sheets; testing for drawing qualities; ductility tests; gage and size tolerances.

Special. Some Special Steels. Engineer, vol. 141, no. 3667, Apr. 9, 1926, pp. 407–408, 5 figs. Describes various applications of several new steels which are made at Hecla Works of Hadfields, Ltd.

Tool. See TOOL STEEL.

STEEL, HEAT TREATMENT OF

Automobile Parts. Reducing Costs in Heat Treating Automobile Parts. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 471–481, 7 figs. Outlines present method of heat treating automobile parts in plant of Reo Motor Car Co., Lansing, Mich., and describes equipment now in use as contrasted with previous equipment; improved methods of handling together with more efficient heat-treating equipment, automatically controlled, have resulted in large savings.

Dilatometric Method. Dilatometric Method of Heat Treatment, O. E. Harder and A. C. Forsyth. Am. Soc. Steel Treating—Trans., vol. 9, no. 3, Mar. 1926, pp. 403–412 and (discussion) 412–419 and 520–521, 11 figs. Report of progress in use of dilatometric method of heat treatment and application of that method to study dimensional changes in such materials as gray cast iron; two slightly different pieces of apparatus were used; details of construction and results obtained.

Quenching. Initial Temperature and Maas Effects in Quenching, H. J. French and O. Z. Klopsch. Am. Soc. Steel Treating—Trans., vol. 9, no. 1, Jan. 1926, pp. 33–68 and (discussion) 68–74, 12 figs. Results of quenching experiments with high-carbon steels in which speed of cooling was determined at center of spheres, rounds and plates of various dimensions quenched from various temperatures into different coolants. Published by permission of U. S. Bur. of Standards.

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TERMINALS, LOCOMOTIVE

Chicago. New Engine Terminal for Illinois Central, W. W. Baxter. Ry. Rev., vol. 78, no. 10, Mar. 6, 1926, pp. 446–454, 19 figs. 48-stall enginehouse and many other modern facilities included in recent improvement.

TERMINALS, RAILWAY

Design. Principles of Engine Terminal Design. Ry. Rev., vol. 78, no. 11, Mar. 13, 1926, pp. 521–524, 1 fig. Report of subcommittee of Committee on Shops and Locomotive Terminals, Am. Ry. Eng. Assn.

Freight. Unification of Railway Freight Terminals E. E. R. Tratman. Eng. News-Rec., vol. 96, no. 9, Mar. 4, 1926, pp. 354–356. Comparisons of multiple-unit system with series of independent parts; examples of experience; interchange service; railway and public interests involved.

TESTING MACHINES

Dynamometer Attachments. Dynamometers and Spring Manometers as Power Recorders of Test-Machines (Ueber Messdose und Federmanometer bei Prüfmaschinen), F. Mohr. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 10, Mar. 6, 1926, pp. 317–322, 12 figs. Investigations of variability of power records obtained with dynamometers and spring manometers used in connection with testing machines of different types; results are shown in calib ation curves; causes of deviations are traced to their sources; points out advantages of dynamometer, and describes new system by Mohr & Federhaff, Mannheim, according to which it is built in testing machine together with sliding-weight scale.

TEXTILES

Printing. Textile-Printing Industry (L'Industrie de l'Impression sur Tissus), B. Bisson. Revue Industrielle, vol. 56, nos. 2198 and 2199, Jan. and Feb. 1926, pp. 3–8 and 49–59, 12 figs. Industrial textile printing involves 12 principal operations and 14 manipulations which are explained and illustrated in plan of printing plant; coloring; different printing processes; preparation of colors; practical examples of different printing processes; machinery employed.

THERMODYNAMICS

Joule-Thomson Effect. The Joule-Thomson Effect in Air, J. R. Roebuck. Am. Academy Arts & Sci.—Proc., vol. 60, no. 13, Dec. 1925, pp. 537–596, 15 figs. Data covering readily available temperatures above that of room; bath liquid above 300 deg. cent. is serious problem; available and useful pressure range. Bibliography.

THERMOMETERS

Resistance. A Small Resistance Thermometer, G. F. Taylor. Phys. Rev., vol. 26, no. 6, Dec. 1925, pp. 841–850, 3 figs. Construction and performance of instrument developed for field observations in Department of Agriculture; main object sought was to produce resistance thermometer which would be comparable in size to thermocouple and thus combine advantages of both.

Resistance Thermometers (Etude sur les thermomètres à résistance), J. Vassillière-Arlhac. Revue Générale de l'Electricité, vol. 19, no. 9, Feb. 27, 1926, pp. 341–346, 11 figs. Formulas for thermometers for temperature measurements based upon almost linear change of ohmic resistance of metals with changing temperature; describes number of methods that have been found most suitable; among these are bridge methods for d.c. and a.c. supply, double moving-coil instrument and compensation connection; points out magnitude of errors inherent in various methods described.

Test Code. Test Code on Instruments and Apparatus. Mech. Eng., vol. 48, no. 4, Apr. 1926, pp. 382–387, 16 figs. Preliminary draft of chapter 3, Temperature Measurement, part 2—Glass Thermometers; general description and classification; expanding fluid; form, glass, immersion; precautions.

TIME STUDY

Methods. Time Study in Industrial Management, J. S. Gray. Machy. (N. Y.), vol. 32, no. 8, Apr. 1926, pp. 613–615. First step in introducing time studies; general methods in time-study work; using time study for intelligent rate setting; time included in and time required for time studies.

TOOL STEEL

Composition and Properties. Facts and Principles Concerning Steel and Heat Treatment, H. B. Knowlton. Am. Soc. Steel Treating—Trans., vol. 9, no. 1, Jan. 1926, pp. 111–132. Composition, properties and uses of common types of tool steels; explains classification of plain carbon tool steel according to grade and carbon content.

Tempering and Aging. Dimensional Changes Accompanying the Phenomena of Tempering and Aging Tool Steels, H. Scott. Am. Soc. Steel Treating—Trans., vol. 9, no. 2, Feb. 1926, pp. 277–304, 6 figs. Shows that contraction with time is identified with initial contraction on tempering and expansion with expansion on tempering which follows initial contraction; this correlation, together with analysis of associated reactions, permits generalizations regarding control of time changes. Bibliography.

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MEJ R.R.

Supplement to the June, 1926, Issue of

MECHANICAL ENGINEERING

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American Society of Mechanical Engineers

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FIG. 1 HORSE-DRAWN, GROUND-DRIVEN COMBINED HARVESTER OF EARLY DAYS. DIFFICULTIES ENCOUNTERED IN ITS USE RESULTED IN THE DEVELOPMENT OF THE TRACTOR

The Development of the Caterpillar Tractor and Its Application to Industry

Historical—Inception of the Idea of the Endless-Track Principle and Its Development into a Workable Machine—The Caterpillar in the World War—Standardization and Refinement in Manufacture—Universal Application to Industry

BY PLINY E. HOLT,[1] STOCKTON, CAL.

THE history of the "Caterpillar" tractor industry can best be reviewed by considering the six distinct periods in its development as follows:

1 Historical, or that period which created the demand for some form of automotive tractor power
2 The inception of the idea of the endless-track principle
3 The development of the caterpillar idea into a workable machine
4 The caterpillar in the World War
5 Standardization of the parts, and refinement in manufacture
6 Universal application to industry.

HISTORICAL

To get at the underlying forces which led up to the development of the caterpillar with its present-day universal application to traction work, we must go back to the conditions and the trend of the times which created the demand for the tractor in its original inception.

The early history of the traction engine began with the first road locomotive, made in England in the early part of the nineteenth century. This development had a rather stormy career and was of importance principally because it was the forerunner of the present-day railroad. There was a long gap between the early road locomotive and the traction engine and automobile used today.

During this long interval there was a constantly growing urge for the application of power in transportation over the roads and across the roadless stretches of country. There was a demand for a prime mover to take the place of animal power and increase the work which a man could do in agriculture and general industry.

The major development of high-power traction engines, using both steam and gasoline, took place on the Pacific Coast. This resulted from the fact that in that section, agriculture, which was the major activity of the country in the early days, was practiced on a very large scale by large landholders. Men were scarce and horses plentiful. This brought about the use of large teams of horses and the use of implements, such as plows and harvesters, in large gangs, so that a large amount of work could be accomplished with a small number of men.

The use of the traction engine for heavy-duty work was brought about largely by the difficulty encountered in handling a large team of horses to haul combined harvesters during the dry, hot season in which this class of work was done (Fig. 1). Along in the latter part of the nineteenth century the demand for some sort of tractor power, which could work more economically in the hot, dry, dusty harvest fields for longer hours, caused quite a number of inventors and manufacturers to attack this problem.

In this work there were two men in the West who stood out as pioneers and who successfully solved the problem; one was Daniel Best, at San Leandro, and the other was Benjamin Holt, at Stockton, California. These two men, with their organizations behind them, developed and built heavy-duty steam tractors which came into use along the latter part of the nineteenth century. While they were designed primarily for agricultural purposes, they were used for industrial work fully as much. They pulled large gangs of plows and farming equipment, hauled lumber and ore where there were no roads, and did pioneer construction work.

These tractors had their limitations. While they were very successful during six months of the dry season, which was characteristic of the West Coast conditions, they could not operate successfully in the winter on account of the mud or slippery sod, or at any season of the year in the sand. These limitations created a desire on the part of the users for a tractor which would work

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under any and all conditions, and regardless of soils, condition of roads, or steepness of grades. In other words, there was a desire to replace the horse by tractive power for all purposes.

At the same time that the development of the large, high-power tractor for the Pacific Coast was going on, eastern manufacturers were developing a smaller steam tractor which was an outgrowth of the old portable engine used for furnishing power for stationary threshing machines. Their use for years was almost entirely limited to hauling threshing machines around the country and furnishing belt power while threshing. It was only in later years that they tried to use these smaller tractors for plowing or other industrial purposes.

The intense rivalry between the two leading manufacturers, their endeavor each to excel the other, and the necessity above all to produce a tractor that would function satisfactorily under all conditions and serve the ever-widening field which began to open up to tractor use, was largely responsible for the rapid development of these powerful tractors.

The limitations of the heavy round-wheel tractor were brought most forcibly to the attention of California manufacturers when trying to harvest and operate on the reclaimed peat lands of the lower Sacramento and San Joaquin Rivers. These lands were

FIG. 2 STEAM TRACTOR BUILT FOR USE ON VERY SOFT GROUND, ILLUSTRATING EXTREME CONDITIONS WHICH CAUSED THE DEMAND FOR THE CATERPILLAR TRACTOR

very soft and practically bottomless, and in the early days of reclamation it was almost impossible for horses, or even men on foot, to stand up on the very soft land. The use of the conventional wheel-type tractor was out of the question.

The manufacturers built tractors with wheels of extreme width. The climax to this was a tractor built by The Holt Manufacturing Company for Chas. Moreing along about 1898, which had wheels about 8 ft. in diameter and 18 ft. in width on each side of the tractor (Fig. 2). This was probably the largest and most powerful engine ever built, but it emphasized the fact that the weight increased almost in proportion to the width of the wheels, so very little was gained by this method.

INCEPTION OF THE IDEA OF THE ENDLESS-TRACK PRINCIPLE

The endeavor to build these wide-wheel tractors to stand up on soft land brought home to Benjamin Holt the necessity of working on an entirely different principle in order to produce a tractor which would perform satisfactorily under the most adverse conditions. Again necessity was the mother of invention. In the early part of 1900 he became convinced that it would be necessary to depart from the old type. He built a pair of tracks, or "platform wheels" as they were called in those days, and installed them on one of the steam tractors. This was a very crude device in which he used shafts, sprockets, and material that was practically picked out of old materials from around the plant. This new type of tractor worked so well that it encouraged him to build another one, and thus the modern "Caterpillar" had its inception.

No one realized at that time how far-reaching that development was to be. Benjamin Holt, and most of his associates, anticipated that it would make only a special-purpose tractor which could be used under abnormal conditions. They then believed that the round-wheel tractors would still be standard for general use, but it took only a few years of experience with these early models to develop the fact that the caterpillar was to be a general-utility tractor.

This was brought most forcibly home to Mr. Holt and his associates by an experience near Stockton where one of their 40-hp. standard steam tractors mounted on caterpillar tracks was used to pull the load formerly hauled by one of their large 60-hp. round-wheel steamers. To their amazement they found that the little tractor not only pulled with ease the load of the large tractor, which consisted of three heavy gangs of plows, but it was able to haul a fourth gang of plows, and pull all four gangs at a two-inch greater depth in the same field and under the same conditions. This experience was the first realization of the superior efficiency of the track over a round-wheel type. It was proved that with the caterpillar tractor the resistance to travel was practically constant on account of the weight's being carried on tracks, which distributed it over a large area of ground, as compared with a round-wheel tractor in which the power required to propel it varies according to the character of the soil over which it is operating.

Gasoline-driven caterpillars were first put in use in 1905. After two years of development on the soft delta lands of the San Joaquin and Sacramento Rivers of California, they did their first heavy industrial work when a fleet was used in hauling heavy materials across the Mojave desert and up roadless mountain sides for the Los Angeles aqueduct (Fig. 3).

Shortly following this period, C. L. Best, son of Daniel Best, began the development and manufacture of gasoline-driven "tracklaying" tractors at San Leandro, which stimulated the rapid improvement of tractors during the period following.

If space permitted, a great deal more could be said about the interesting and romantic history connected with the development of the early tractors in California. Their history was closely interwoven with the agricultural and industrial growth of the West, until their influence extended over the entire country and came to play an important part in world affairs.

DEVELOPMENT OF CATERPILLAR IDEA INTO A WORKABLE TRACTOR

The second stage, or the development stage of the caterpillar, lasted over a period of about ten years. During that time the builders passed through various stages of ridicule, questioning of sanity, finally an attitude of tolerance, and just before the beginning of the World War a realization on the part of the world at large that the caterpillar tractor was a useful piece of machinery and one that would be largely used. But even at that time it was not regarded as a machine which would ever become universally used for all tractor purposes, as has since proved to be the case.

The World War found the tractor fairly well advanced through the development stage. It would run well and make a fine demonstration; it would do useful work, pull a good number of plows, a train of wagons, heavy road graders, etc. Up to that time, however, little thought had been given to the cost of operation, and whether it was an economical piece of machinery to purchase. This part of the problem was being worked out when the war came on, and attention was being given to the economical use of this type of tractor in its various fields of work, and methods were being found to increase the life of the machine.

THE CATERPILLAR IN THE WORLD WAR

About two years prior to the World War the German Government and Austro-Hungarian landowners had become large purchasers of caterpillar tractors, and had them pretty well in use throughout the German Empire. It was later revealed that these tractors, in their prewar agricultural work, were operated by soldier drivers detailed by the military authorities for that purpose. The Holt Manufacturing Company had no intimation of the military uses planned for these tractors until they received the news of the Belgian invasion, when they found that the caterpillar tractors which had been purchased by the land barons of Austria-Hungary were in reality purchased for use by the military services to batter their way through Belgium.

The English captured one of these tractors in the early part of the war, and it has been proved by the testimony of Gen. Sir Ernest Swinton in the recent trial in England to establish the true origin of the tank idea, that this tractor which he saw, and which was one of the tractors formerly owned by the German Government, was the basis upon which the English developed the design

of the world-renowned tanks. It was this tractor, too, that caused their government to immediately get in touch with the Holt Company and arrange for delivery of as many of these tractors as could be furnished throughout the duration of the war.

An interesting story connected with the early development of this use by the British Government relates to the first tractor which they bought for trial purposes. This tractor, which was one of the largest built by the Holt Company, had been purchased by Franz Joseph of Austria-Hungary for use on one of his estates. It was painted Franz Joseph's colors and bore his coat of arms, and was boxed and resting on the docks at New York awaiting shipment when the war broke out. An order came from England for a trial tractor, and representatives of the Holt Company broke open the box, painted out the Austro-Hungarian colors, repainted it with a neutral color, and shipped the same tractor to England for the English Government to submit to field tests preparatory to placing with the firm an order for continuous production.

The part of the caterpillar tractor in the World War is too well known to need repeating. The transportation of heavy guns and ammunition over the soft ground, across shell holes, and up steep hills where no roads existed, was a vital problem of the war. It was solved by the use of caterpillar tractors and the use of caterpillar designs. The giant tanks were the outgrowth of caterpillars converted from peace-time and pastoral uses to the stern requirements of war.

During the period of the war and up until 1921 the caterpillar went through a very intensive study on the part of the engineers for the Allied Governments and the engineers of the Holt and Best Companies, as well as the engineers of other companies manufacturing tractors using the crawler or track-layer principle. To show to what extent development was effected by this intensive study, it can be noted that the modern tractor now built by the Caterpillar Tractor Co. has over 4000 fewer parts than were used in the wartime tractor.

Since the close of the war the U. S. War Department has maintained a continuous contact with the development and production of the caterpillar tractor.

An officer of the Ordnance Department, experienced in tractor and tank work, is continuously stationed in the factory at San Leandro. He serves as the point of contact between the Caterpillar Tractor Co. and the War Department, keeping the Government constantly informed of progress and development along all lines of interest from a military standpoint.

Standardization of Parts and Refinement in Manufacture

The successful tractor of today must be one of the most carefully designed and well-balanced pieces of machinery possible to produce. After a moment's thought it will be realized why this is the case. A tractor has to endure much greater abuses than almost any piece of machinery of its kind in use today. First, the tractor is uniformly loaded to practically full load at all times. Second, it has to work under the most adverse conditions of dust, dirt, mud, sand, and grit, which will attack its finely constructed working parts through the air intake and breather, and through every moving joint or possible opening, unless thoroughly excluded. Third, the tractor must run year in and year out, and frequently day and night, as will be evidenced by the number of uses to which it is now being put.

Today the caterpillar is built from the best materials obtainable for each particular part, considering the use to which it is put. Each part subject to wear or unusual strain is then given the most thorough and scientific heat treatment, and subjected to the most exacting tests known to the automotive industry. The tolerances and general workmanship are held closer than in any other automotive device built, or as close. The engines have to be built better than the average gas engine for the reasons stated.

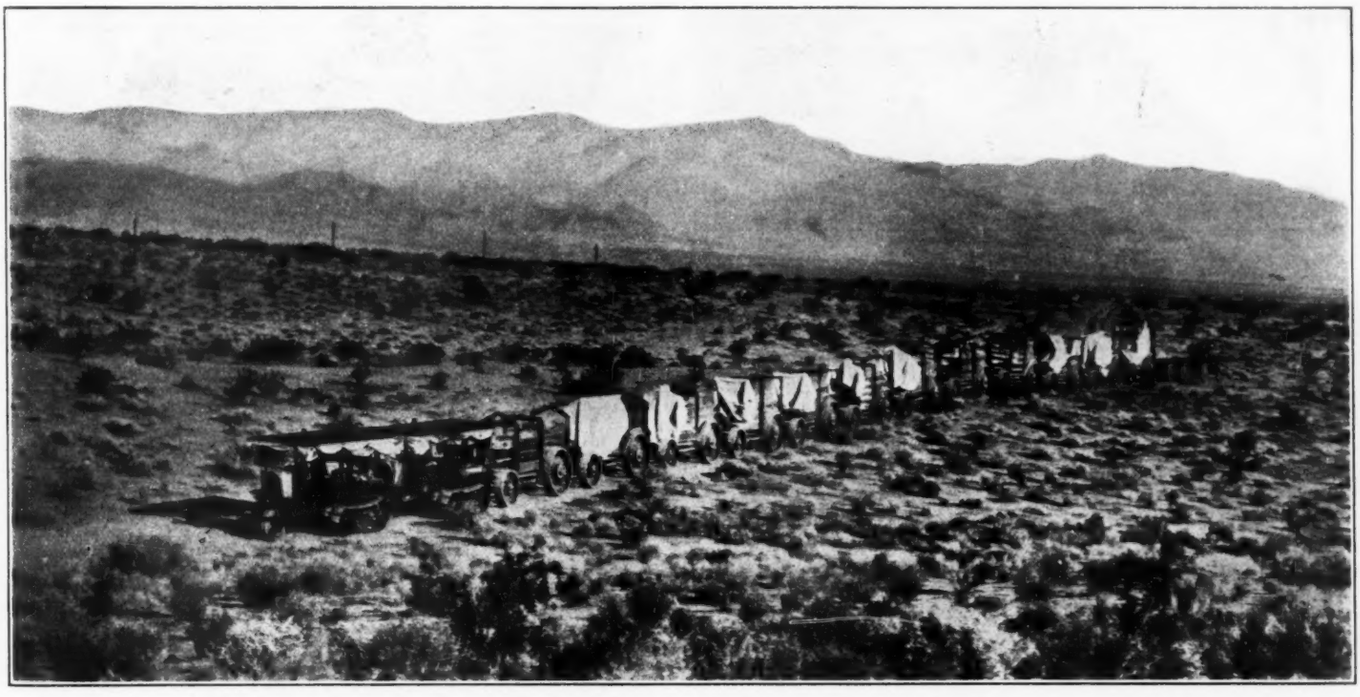

FIG. 3 FIRST GASOLINE CATERPILLAR TRACTORS HAULING MATERIAL ACROSS THE MOJAVE DESERT FOR THE LOS ANGELES AQUEDUCT IN 1908

The problem of dust and grit exclusion from the engine and from the bearings, has cost the Caterpillar Tractor Co. and its two predecessor companies many thousands of dollars in research and development work to solve. It is gratifying to state that it is now solved for all practical purposes, though the company is still striving for betterment.

The most intensive study has been given to securing a long-lived foolproof machine with a low maintenance cost, which will perform its work at the lowest possible ultimate cost to the user. The refinements of design and manufacture here briefly outlined, together with a simplification of the machine, provision for easy accessibility and its better adaptation to the job, coupled with a thorough standardization of all parts, have gone a long way toward the realization of this ideal. The greatest progress has been made during the past few years, giving a product so far superior to the wartime models as to make comparisons useless.

These results in tractor building were not obtained suddenly, as by magic, nor by the mere expenditure of large funds, but stand as the result of many years of experience in building, testing, improving, and servicing tractors under all known conditions. It is the patient and conscientious work of a large corps of engineers

and builders who have concentrated for years on one thing, determined to excel in that one line.

It was most fortunate for the caterpillar that the two companies developing it were located in California where there exist the greatest variety of extreme conditions of soil and severe tests for tractors to be found anywhere. This permitted each step in its evolution to be given a practical testing out in the field, close at hand and under constant observation of the builders.

There is soft, boggy peat land to be reclaimed and cultivated, hard adobe to be plowed, and the toughest kind of deep hardpan to be "busted" in subsoiling, as well as the most ideal orchard and garden land to be tilled without packing. There is much sandy and gritty soil to be found in most parts of the state, which, with

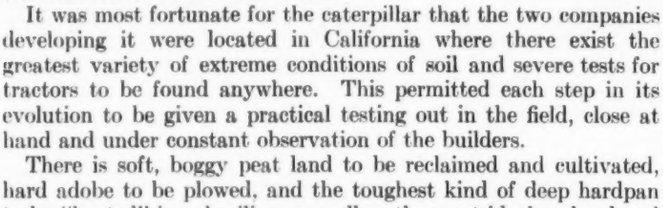

FIG. 4 CATERPILLAR TRACTOR HAULING A CULTIVATOR

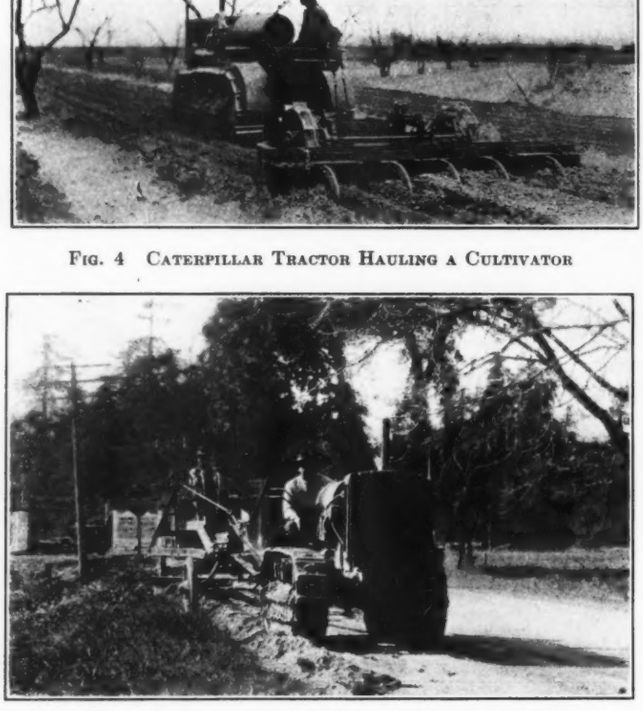

FIG. 5 CATERPILLAR TRACTOR WITH BLADE MAINTAINER WORKING ON SHOULDER OF A CONCRETE ROAD

the severe dust conditions often prevailing in rough work and the sandy deserts to be found on freighting jobs, present in extreme amount the most deadly enemy of tractors—abrasive in the form of dust and grit.

There are the heavy, tough construction jobs, the steep mountain grades, the rocky trails, the big logs to be handled under the roughest kind of mountain logging conditions, and, by no means least, a type of tractor user determined to do the job in a bigger way than his neighbors, and with little sympathy for the tractor.

It is natural that a tractor born and brought up under such conditions and steadily improved and toughened to resist them, can be expected to survive to maturity, since, as in nature, it is a case of "the survival of the fittest."

APPLICATION TO INDUSTRY

While the caterpillar tractor started out as an agricultural implement, the first large order sold, and the largest order that had ever been taken for tractors up to that time, was for industrial purposes. These were used by the Los Angeles Aqueduct during the years 1908 and 1909. At the same time large oil companies and railroads bought tractors for transportation and pioneer construction work. Today, to enumerate the uses of the caterpillar would carry one over practically every kind of outdoor work in the world.

Agricultural usage has become secondary to industrial, although it must be borne in mind that even in agricultural work the caterpillar has a far broader field of utility today than would have been thought possible a few years back. New agricultural tools, such as giant subsoilers and gopher plows, heavy cultivators, and land levelers have been developed—tools that can be successfully utilized only when liberal power and sure traction are available. Tractor-drawn combined harvesters have also come into more general use. The development of a successful small caterpillar has served to broaden the field of use in both agriculture and industry.

The industrial possibilities of the caterpillar seem almost unlimited. Road building, of course, is the biggest field, and includes not only road grading but also the handling of many other road operations, such as the clearing of land, pulling stumps and trees, making cuts and fills, using a bulldozer to fill in around culverts and bridge heads or widen embankments, maintaining dirt and gravel roads or shoulders of paved roads, building and cleaning ditches, constructing subgrades for paved roads, hauling paving materials, etc. Caterpillars are used for all these purposes by states, counties, townships, and by contractors who do road work under contract.

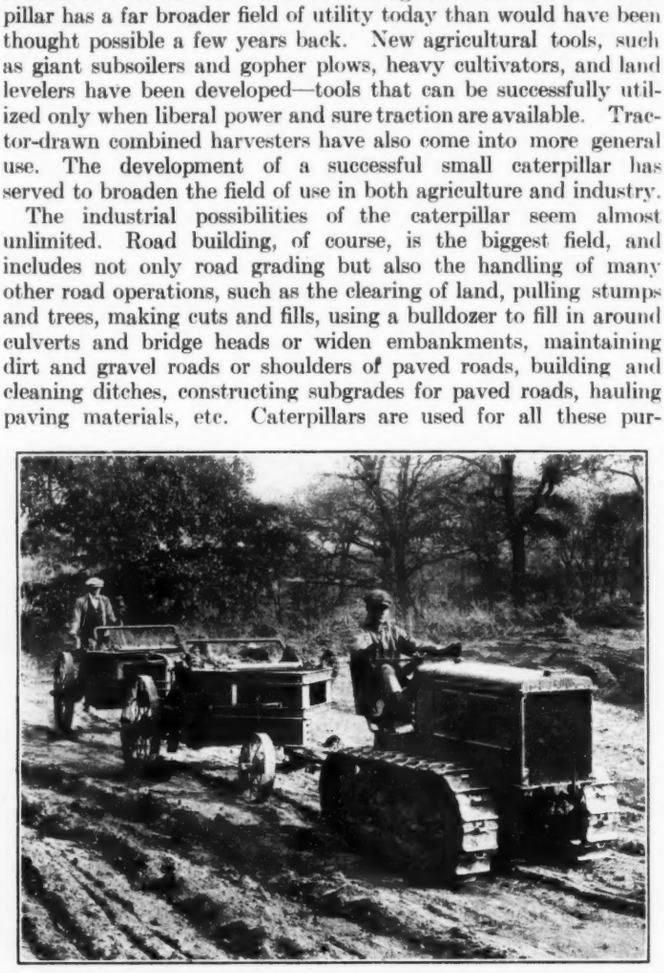

FIG. 6 CATERPILLAR TRACTOR HAULING WHEELED ROAD SCRAPER

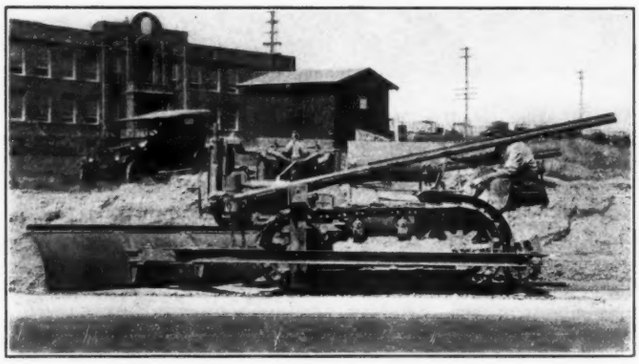

FIG. 7 CATERPILLAR TRACTOR BACKFILLING A PIPE-LINE TRENCH

Municipalities use caterpillars for refuse hauling, garbage disposal, park construction and maintenance, and many other purposes. Both cities and counties, as well as bus transportation companies, street railways, industrial plants, and others, use caterpillars for snow-removal purposes.

Caterpillars have a wide field of usefulness in the woods. In the Sierras of California and in Oregon and Washington they are used to transport 20-ton loads of logs carried under the arch of a mammoth two-wheeled carrier built of steel and equipped with hydraulic lift actuated by tractor power. In the big Coast timber the front ends of big redwood or Douglas fir logs are carried on low-wheeled or track-laying "bummers" or "dollies."

In the "Inland Empire" the logs are skidded on the ground, or dragged in long tandem strings on the ground or in specially built chutes. From the landing, if rail or water transportation is not available, the tractors haul the logs to the hill or market on wagons. They are used in large numbers for such hauling in the mahogany operations of Central America. In the northern woods of the central and eastern states and Canada, caterpillars are largely used for hauling logs and paper-pulp wood on sleds during the winter months, over snow or iced roads. In some cases sled trains of from 200 to 300 tons are drawn. In the southern lumber belt the hauling is usually done on eight-wheeled trailers.

The caterpillar has other uses in industry, so varied and so manifold that only brief mention of them is possible. The tractors haul lumber, pulp wood, cordwood; work in clay, gravel and sand pits, in mines and quarries, in brickyards and in tile works. Caterpillars are serving oil-well development and exploration in both domestic and foreign fields, and they build roads and freight pipeline materials and machinery in the developed oil fields. They are working on levee and revetment projects, canal construction, dam and reservoir building, reclamation projects, and town-site and subdivision developments. Railroads use these tractors for construction work, power companies for clearing the pole-line right of way, and for hauling poles and cable reels. For stadium construction, and for baseball-park, race-track, amusement-park, golf-course, and cemetery construction and maintenance, tractors have found wide usefulness. They are used for moving houses or transporting heavy machinery of various kinds. Municipalities and public-utility companies use them for sewer and gas- and water-main work. With a backfiller mounted in front of the tractor (Fig. 7), backfilling of trenches is quickly and easily accomplished at a remarkable saving in cost.

Caterpillars find many industrial uses in and around steel plants, glass and pottery works, paper and lumber mills, cement and chemical works, foundries, sugar refineries, etc.

It is impossible to completely catalog the caterpillar's uses, as new fields of usefulness are constantly being discovered and devised.

The Caterpillar Tractor Co. is giving much thought and work to the matter of assisting every manufacturer of tools or implements designed to work with caterpillars, in order to make the two work together most effectively in doing the world's work. There is a special department of the company in charge of a research engineer handling this line of work.

In the past many unique applications have been worked out by implement manufacturers or by the tractor purchasers themselves. Oil-field purchasers have devised special winch and drilling equipment mounted on the tractor for servicing oil wells. One power company attached to the small tractor a large pole-hole auger. Several road-machinery manufacturers are bringing out one-man road graders and one-man maintainers attached to caterpillar tractors. The machines are usually controlled by the tractor driver, power for operating the blade and scarifier being derived from a power take-off on the tractor transmission.

Much development work is under way by various equipment companies with a view to bringing out larger and better tools to be operated in connection with, and controlled by, power taken off the tractor. One of the most remarkable at present is a 12-cu-yd. telescoping scraper pulled by a 60-hp. tractor and controlled completely by electric motors receiving power generated on the tractor and operated by switches at the tractor driver's seat.

The development of labor-saving power equipment to be operated with caterpillar tractors has only begun, and great progress is expected in this direction during the next few years. It offers a good field for mechanical engineers interested in such types of equipment.

With the progress made in perfecting caterpillars and the work under way on auxiliary equipment, the future of this type of prime mover in industry is assured.

Water Power and Steam Power in California Utilities

A Brief Analysis of the Power Situation to Determine the Respective Contributions of Water Power and Steam Power to Existing Conditions, and Their Probable Future Effects

By H. A. BARRE,[1] LOS ANGELES, CAL.

THERE has always been more attendant publicity in connection with the development of water power than there has with the development of steam power. This widespread publicity, coupled with the existence of low rates and the almost universal use of electric service in California has apparently given rise to the impression that water power has been the cause of these desirable results.

A brief analysis of the power situation to determine more clearly the respective contributions of water power and steam power to the existing conditions of the industry and their probable future effects may be of interest.

There can be no question that if no water power had ever been developed in the state there would have been just as many kilowatt-hours sold annually as there are today. The use of electric power does not depend upon production but on market and distribution. Experiencing her most rapid development during a period when the advantages of electric-power supply from central stations had become well known, California supplied the market. Enterprising managements of electric utilities, recognizing the condition and aided by the rapid progress in the art of distribution, built the electric systems and by aggressive solicitation of business developed the market for practically a universal use of central-station electric power. That some part of the power supply came from water-power sources was incidental to the controlling factors of market existence and the presence of enterprising men willing to furnish the market with an electric-power supply.

Probably the most important contribution of water power to the industry is the fortunate fact that practically all the water powers are located at a distance from centers of utilization and that it was necessary to develop the art of transmission at higher and higher voltages to deliver the power to the towns. Shortly after the earlier of these water-power plants began to transmit electric energy to the towns, uses for power rapidly sprung up along the line in the outside country, and the amount of energy received by the towns from original sources of production began to decrease until the condition arose that at the seasons when water power was abundant, some power was delivered to the towns, while during the season of low flow of the streams, power generated from other sources flowed back from the larger cities to the country and the smaller towns.

The fluctuating character of the California streams also played a part in broadening the use of electric power, particularly in rural districts. Available water power occurs at its maximum during the rainy season and the early summer when the streams are filled from melting snow. In the late summer and fall low stream flows reduce the water-power supply. The heavy lighting loads occur during the early winter, usually before the streams begin to rise. Surplus water power in the early spring and summer, as well as the steam resources held for the winter peaks, made it possible to serve a summer irrigation-pumping load by the extension of the distributing system and with a minimum of generating plant.

The extension of country lines to serve irrigation-pump motors made possible further service of lighting and other domestic and industrial applications in outlying sections, and still further broadened the field of use of electricity.

It is conceivable that with the improvements that have been made in the art of steam generation during the past fifteen years and with the comparatively low prices of fuel oil that have accompanied the development of the California oil fields in the same years, the cost of electric power in the cities could perhaps have been made as low as if served from the present systems of coördinated water powers and steam plants, but the extension of service to smaller communities and rural districts would probably have been slower in reaching its present density. In this connection it is interesting to note that those few companies in California which operate solely on steam power sell service at practically the same rates as those having water power, and have as high financial standing.

California water powers arrange themselves into two classes:

1 Those utilizing water storage during the dry season by means of either natural or artificial reservoirs
2 Those using the unregulated natural flow of the streams.

The latter must be considered mainly as auxiliaries to a steam plant, since as a whole a steam installation of at least 75 per cent of their installed capacities is required to produce primary commercial power.

The former require small steam reserves and permit of highly efficient steam operation, since water deficiencies may be made up in kilowatt-hours by twenty-four-hour operation of steam plants, while reservoir plants are available to carry peaks up to any predetermined draft on stored water.

Obviously, then, coördinated systems of steam and water power are needed for the maximum use of water resources. It is also apparent that a 100 per cent water-power supply is not desirable since this would mean that water powers would be developed for only the minimum flow of the stream and all the kilowatt-hours in the water in excess of the minimum would not be developed. In California, and in fact all over the world except in a very few exceptional cases, the amount of such a minimum power is so small that it would not form a satisfactory supply for commercial power systems.

This condition of stream fluctuation emphasizes the futility of statements that are frequently made by economists, congressmen, chambers of commerce, and others that a certain territory has a potential resource of a certain number of horsepower of water power. Without the qualifying knowledge of the amount of coordinating steam needed, such a statement is worthless as a measure of the value of the territory as a power producer. The whole economic situation from a power viewpoint must involve flow characteristics, cost of fuel, economy of steam plants, and cost of plants of both kinds.

The high economies that have been obtained in the recently completed steam plant of the Los Angeles Gas & Electric Company at Seal Beach, and the Southern California Edison Company at Long Beach, have made a decided difference in the situation. While the older steam plants in California have economies of 200 to 260 kw-hr. per barrel of oil under full-load conditions, the economy of these new plants is of the magnitude of 425 to 450 kw-hr. per barrel. At such efficiencies the fuel cost with oil at $1 per barrel ranges around $2\frac{1}{4}$ mills per kw-hr., a figure so low that additional stream-flow plants in California are practically out of the question, and plants having storage facilities must be scrutinized more carefully than heretofore. Only an increase of several hundred per cent in the price of fuel can change this condition.

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Oil Engines as a Drive for Pipe-Line Pumps

A Survey of the Use of Diesel Engines for This Purpose, Covering Facts Pertaining to Pipe-Line Systems Leading Out of the Mid-Continent Area, Together with a Discussion of Pipe-Line Practice and of Forms of Power Previously Employed

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PROBABLY the least-known industry in this country today, considering its size and importance, is the pipe line for the transportation of crude oil. It is consequently also true that very little is known, in general, or even in engineering circles, of the extent to which the Diesel engine has been used in this industry. Pipe lines were among the first to give the Diesel engine a trial and to adopt it in a large way as a standard form of power. Thousands of these engines have been installed in pipe-line pump stations, where a real service is demanded of them, and many large systems have been operating entirely with this form of power for almost a decade with excellent results and a good saving in money.

It is the author's object to present a survey of the use of Diesel engines in this field, covering only the facts as they pertain to pipe-line systems leading out of the Mid-Continent area; and since so little is known of pipe lines, he deems it fitting to include a few figures to show the importance of the industry, to explain to some extent pipe-line practice, and to review briefly the forms of power in use previous to the Diesel engine.

The Pipe Line—A Billion-Dollar Industry

From a rather inauspicious start some sixty years ago in the Pennsylvania oil fields, the pipe-line industry has experienced a very remarkable growth. Considered at first as feasible only for eliminating the team and flat boat in short hauls from field to refinery, the pipe line has become the method of cross-country transportation of oil. It has almost completely replaced the railroad for this purpose. Great trunk lines span half the continent, and almost the entire daily oil production of the country pulsates through these underground arteries. It has been estimated that it would require two million tank cars and ten thousand locomotives, in addition to what are now in use, to transport by rail what is handled by pipe lines. There are now six trunk lines from the Mid-Continent fields to the Gulf and three from the Mid-Continent fields east. Some of these systems are made up of from two to seven parallel lines, with pipe as large as 12 in. in diameter. In the entire country there are some one hundred thousand miles of pipe lines in operation, representing a total investment of well over a billion dollars. The nine Mid-Continent pipe lines mentioned have some thirty-five thousand miles of lines representing an investment of about $350,000,000. The largest of these companies has a pumping capacity of 200,000 bbl. or 8,500,000 gal. per day. If this were water it would be sufficient to supply a city of over 100,000 population. To get some idea of the power required, however, it should be mentioned that this stream is pumped at about ten times the pressure usually found in city water supplies.

Present-Day Pipe-Line Practice

All pipe-line systems can be divided into main lines and gathering lines, much the same as a railroad, except that this division is more distinct in the case of a pipe line. Altogether different principles are applied in both the construction and operation of each classification. Trunk lines are, as a rule, permanent for at least a number of years and are built accordingly, whereas the life of a gathering line is determined wholly by the period of production of the local pool served, which makes it rather temporary.

Main-line practice consists in laying one line, or parallel lines, of 6-, 8-, 10-, or 12-in. pipe in as straight a line as feasible across the country from the group of territories to be served to the delivery points, with a pump station located about every forty miles. Each station pumps into receiving tanks at the next station (usually of 35,000 or 55,000 bbl. capacity), from which the oil is again picked up and pumped to the next station. Seven hundred pounds per square inch is the usual pressure maintained on the pumps. At this pressure a single 8-in. line 40 miles long will carry approximately 20,000 bbl. per day. Pumps for main-line stations are therefore usually of 20,000 bbl. per day capacity for smaller stations where there are but one or two lines, and from 30,000 to 40,000 bbl. per day capacity for the larger stations having multiple discharge lines. Horizontal duplex and triplex single-acting tandem plunger pumps of from 4 in. to $6\frac{1}{2}$ in. bore and of from 18 in. to 36 in. stroke are the most commonly used. The engine capacity required for driving the pumps is roughly 15 hp. for each 1000 bbl. per day pump capacity for the 700 lb. per sq. in. fluid pressure maintained.

Gathering-line practice consists simply of locating small stations in convenient places in the oil pools as they are brought in, usually in a low spot somewhat down stream from the pool so that the oil can be brought to the station by gravity, and running discharge lines from these stations to the nearest points on the main line. In this case the size of the line, the distance pumped, and therefore the pressure and power required for different capacities, may be almost anything, depending on the local conditions. The units therefore range in size from a 3-in. by 10-in. duplex piston pump driven by a 25-hp. engine, to a full-sized main-line pump driven by a 300- or 400-hp. engine.

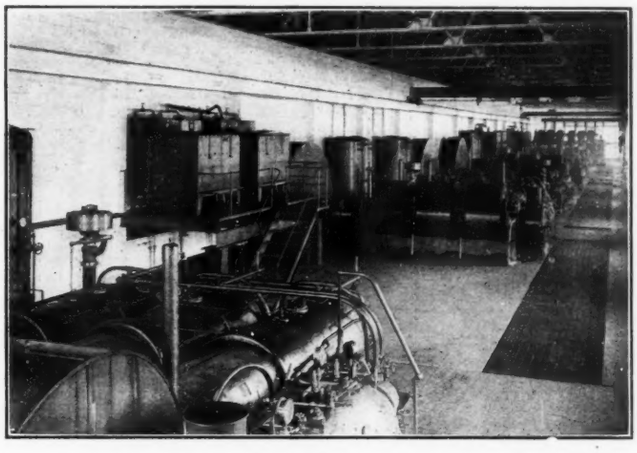

Fig. 1 Engine Room of a Large Horizontal-Engined Pump Station on the Prairie Pipe-Line System, Located near Buckner, Mo.

(This station contains five 600-hp. three-cylinder, four-cycle, horizontal engines. One 600-hp. six-cylinder, four-cycle, vertical engine can be seen at the far end of the room. Each engine here is equipped with a centrifugal purifier, belt-driven from the shaft coupling.)

It is on the main-line stations that the best Diesel-engine practice is followed. These are the real power plants of the pipe lines, and it is this field mainly that will be covered here.

To complete the description of pipe-line practice it should be mentioned that all stations are operated on a 24-hour basis, by three 8-hour shifts, or "tours" as they are called in pipe-line parlance, and that all stations of a system are in constant communication with each other and with central points through an independent telegraph system whereby oil is despatched by orders much the same as trains are on the railroad.

History of Pipe-Line Power

The first pump to be used on pipe lines was a simple single-cylinder pump attached to a pin on the flywheel of a single-cylinder steam engine. The steam consumption of such a unit was probably 25 to 30 lb. per hp-hr. The next form to be used was a single-

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cylinder direct-acting pump, without a flywheel, and this was in turn replaced by a duplex pump of practically the same design. The change from the flywheel pump to the duplex was rather a retrogressive step, for the latter has practically no cut-off and the steam consumption is anywhere from 150 to 200 lb. per hp-hr. In spite of its poor economy it was the standard form of pipe-line power for many years. Its popularity can be explained by its simplicity, low first cost, and general flexibility. Many thousands of such pumps, in small sizes, are still in use today in the oil fields and in refineries. For pipe-line stations these duplex pumps were built in sizes having steam ends as large as 30 in. in diameter for fluid ends 5 in. in diameter. Some attempt at economy was made by compounding the cylinders, which lowered the steam consumption to perhaps 130 to 150 lb. per hp-hr., and some were even run with condensers, which further reduced it to perhaps 40 or 50 lb. per hp-hr. But when very much larger units were required, such poor economy could not continue.

In 1890 the triple-expansion steam pumping engine made its appearance on pipe lines. Due to its comparatively complicated mechanisms it met with much opposition at first, but soon replaced all former equipment. When run with a condenser this type of engine has a steam consumption of about 15 lb. per hp-hr. For main-line stations such pumps were built in units of 35,000 to 40,000 bbl. per day capacity, which amounts to about a 600-hp. rating, and cross-compounds of from one-third to one-half that size but with practically the same steam economy were used for intermediate capacities. Many of these units are still in use today. Where cheap coal is available for burning under boilers or where there are other considerations, such as the exhaust steam being required for heating very heavy oil to make it flow through the line, or where very old existing plants have been almost entirely depreciated, as is the case on the Eastern lines, such units are apt to remain in use for some time to come. The steam engine's dependability, low maintenance cost, comparatively low fuel consumption, and its ability to carry overloads—which is often required on pipe lines—made it hard to beat for this service. It was called the "Old Reliable" and was the standard form of power for twenty-five years. But on the lines leading out of the Mid-Continent field, where oil only is to be considered for fuel, it has now been almost completely replaced, in spite of its other merits, by the Diesel engine, which has a still better fuel economy and has shown itself as amply qualified to meet all pipe-line requirements.

Roughly, the steam pumping engine required 1.5 lb. of oil burned under boilers for each hydraulic horsepower developed in the pump, while the Diesel engine consumes but a third of that amount for the same performance. This amounts to a saving of 1 lb. of oil per hp-hr., or about 25 bbl. per hp-year for the Diesel engine figured on 80 per cent load factor. This is not the whole story of course. There are other considerations to be taken up later. But this saving in fuel amounts to something like a million and a half barrels per year when applied to the total oil-engine equipment in operation for either of the first two companies listed in Table 1. This is quite an item, and it might be mentioned here that even if other costs connected with Diesel-engine operation nearly offset this saving in fuel, a change to such type of power would be well warranted from a conservation standpoint alone.

TABLE 1 DIESEL-ENGINE EQUIPMENT IN USE AT THE MAIN-LINE STATIONS OF A NUMBER OF MID-CONTINENT COMPANIES

Name of pipe-line company	Approx. miles of line in operation	Number of oil-engine-driven main-line stations	Types of Engines: Horizontal 4 cycle 1-Cyl. No.	Hp.	Horizontal 4 cycle 2-Cyl. No.	Hp.	Horizontal 4 cycle 3-Cyl. No.	Hp.	Vertical 4 cycle 3-Cyl. No.	Hp.	Vertical 4 cycle 4-Cyl. No.	Hp.	Vertical 4 cycle 6-Cyl. No.	Hp.	Vert. 2 cycle 3-Cyl. No.	Hp.	Vert. 2 cycle 4-Cyl. No.	Hp.	Total main-line oil-engine equipment No.	Hp.	Main-line auxil. engines No.	Hp.	Gathering line station oil-engine eq'p't No. Sta's	No. Eng's	Total Hp.	Remarks
Prairie	11,400	33			9	150	26	300	9	500	16	300	10	665	3	600			1	750	121	50,560	33	1,020	87	138	8,700	10 additional main-line steam stations 22 trip. pumps 13,000 hp. 7 cross-comp. pumps 1600 hp. 30 100-hp. engines listed in gathering eq'p't solid injection
							8	360	15	600			12	500														
													8	400														
													2	550														
													2	365														
Sinclair	6,000	49			6	300			7	300	17	500	4	600	6	750	6	750	1	28	52,010	49	1,800	73	106	7,250	No steam stations
					40	250					6	520					10	440										
					6	200					12	400																
											6	365																
											10	250																
Oklahoma	1,400	15			29	300	2	500			6	400	1	600					38	12,700	15	600	16	21	1,700	2 additional main-line steam stations 4 trip. pumps 2400 hp. 7 cross-comp. pumps 1600 hp.
Standard of La.	2,000	11	43	100	36	300			5	300									98	18,700						6 additional main-line steam stations 6 trip. pumps 3600 hp. All hor. engines shown are solid-injection; all gathering stations, steam
			14	150																						
Gulf	3,300	19	110	100	3	200													133	14,600	19	475				
			20	150																						
Ozark	1,000	10					40	250											40	10,000						
Magnolia	2,900	27	100	100	17	360					2	150							127	17,480	27	525	48	73	3,650	3 360-hp. hor. engines, solid-injection 1 100-hp. hor. engine, solid-injection
			4	140	4	200																				

First Trials of Diesel Engines

To the author's knowledge the first trials of Diesel engines for pump-station use were made in 1913 simultaneously by several of the companies. One such installation was made at Neodesha, Kan., another at Caney, Kan., on The Prairie pipe-line system, and still another at Jenks, Okla., on the Oklahoma pipe-line system. These were all of the semi-Diesel, or hot-plate, type of engine. In each case several 100-hp. four-cycle horizontal single-cylinder engines, coupled to vertical triplex pumps of about 7000 bbl. per day capacity, were set up to compete directly with existing steam plants on these lines. Due to overloading of the engines, inexperienced operators, and other factors explained later, much grief was experienced in these first tests. The results showed no great net saving in money. But the trials demonstrated that the oil engine could hold its own in the way of service demanded on pipe lines, and the future possibilities were readily seen. A year later two larger installations consisting of two-cylinder 300-hp. engines, each of the same type, were set up at other points, and at about the same time an entire oil-engined line, of four pump stations 200 miles long, was built across the state of Missouri. Other installations followed rapidly. In 1926 the full Diesel engine in larger sizes made its appearance on pipe lines, and about a year later all Mid-Continent companies were engaged in extensive programs of converting their old steam equipment to Diesel-engine drive. In the meantime many new lines were built, and existing lines increased, with oil engine as original equipment. The greater part of the Diesel-engine equipment listed in Table 1 was installed between the years 1917 and 1923.

Classification of Equipment

Table 1 is a classified summary of the Diesel-engine equipment in use at the main-line stations of several of the Mid-Continent companies. Where they have been available the totals only of the main-line station auxiliary engines and of the gathering-line station equipment have been included simply to show the total horsepower in operation. It will be noted that there is a great variety of types of engines in use. The makes of the engines listed

represent nearly all of the well-known American builders, such as De La Vergne, Snow, McIntosh & Seymour, Busch-Sulzer, Fulton, Nordberg, and Allis-Chalmers. The earliest tendency was toward four-cycle horizontal engines, the next toward four-cycle vertical engines, and the latest tendency has been toward the two-cycle verticals, especially in the larger sizes. Very few of the horizontal engines listed have been installed since 1920. The total figures given should convey to the reader some idea of what it has meant to the pipe-line companies to install this number of engines and pumps, mainly in a period of about six years, and to obtain and train the necessary operators for such a radical change in the type of power in so short a time.

DIESEL-ENGINE PRACTICE IN PUMP STATIONS

Figs. 1 to 11 are exterior and interior views of pump stations of several of the Mid-Continent lines and represent typical layouts of nearly all of the different kinds of main-line stations to be found in operation today.

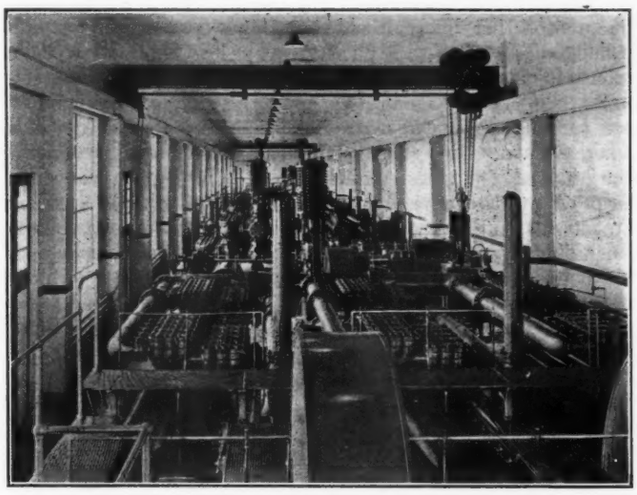

FIG. 2 PUMP ROOM OF STATION ILLUSTRATED IN FIG. 1

(The firewall on the right is identical with the wall seen on the left in Fig. 1. The two air chambers in the foreground are on the suction side of the pump. Note the spring-and-plunger type of alleviators in use on the discharge lines at this station.)

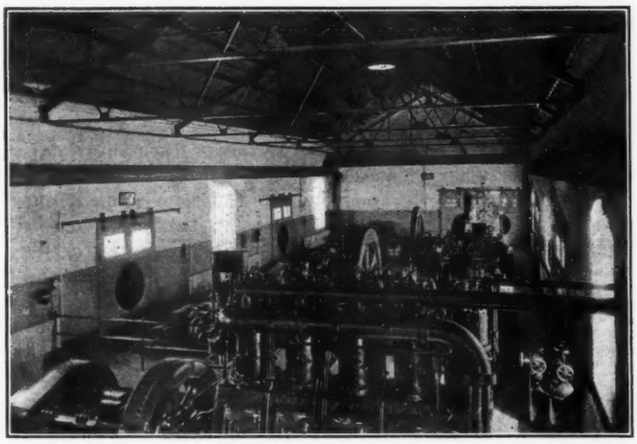

FIG. 3 SOUTH END OF SINCLAIR PUMP STATION NEAR SYCAMORE, KAN.

(Note the absence of a firewall in this part of the station. The equipment consists of one 250-hp. four-cylinder, four-cycle, vertical engine and two 250-hp. two-cylinder, four-cycle, horizontal engines. Through the door at the far end of the room can be seen the room in which are housed the two large engines shown in Fig. 4.)

It is the universal practice to have all main units directly connected to the pumps, usually through herringbone gears of about 1 : 5 or 1 : 6 ratio so that the speed of the pump is from 30 to 40 r.p.m. It is also the rule to have a flexible coupling on the pinion shaft between the engine and pump.

Common practice at first was to have a multiple number of small engines and pumps (about 100-hp. engines and 7000-bbl. per-day pumps) even for larger stations in order to obtain any

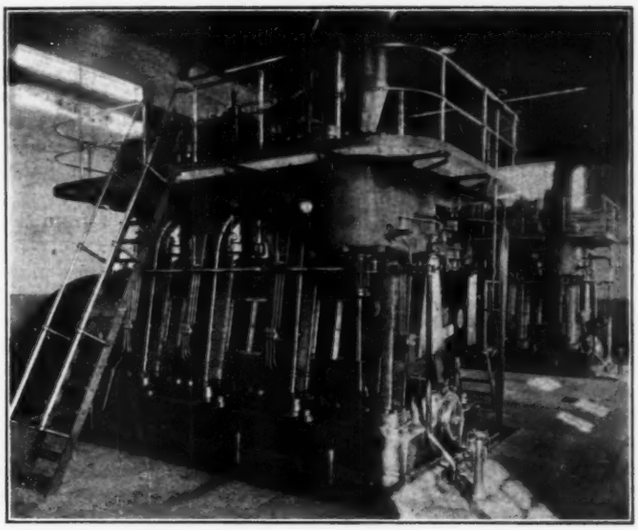

FIG. 4 TWO 750-HP. THREE-CYLINDER, TWO-CYCLE ENGINES IN THE NORTH ROOM OF THE SINCLAIR PUMP STATION NEAR SYCAMORE, KAN.

(The wall to the left is a firewall.)

FIG. 5 PUMP STATION OF THE PRAIRIE PIPE LINE COMPANY NEAR CANEY, KAN.

(Sleeves on the exhaust lines, for obtaining hot water, can be seen between the building and the mufflers. The exhaust stacks, close to the building, are outlets from exhaust radiators shown in Fig. 6.)

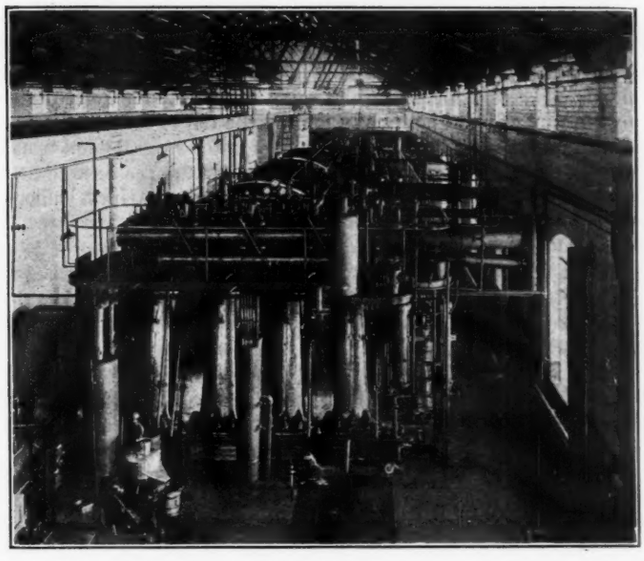

FIG. 6 ENGINE ROOM OF A LARGE VERTICAL-ENGINED STATION OF THE PRAIRIE PIPE LINE COMPANY NEAR CANEY, KAN.

(This station contains six 500-hp. four-cylinder, four-cycle engines, only five of which can be seen here. The sixth engine is at the far end of the room and to the left of the center crane-runway beam. The second, third, and fourth engines are faced at a 90-deg. angle with the engine in the foreground. These engines drive pumps which have their power ends in this room and their fluid ends in the pump room. Note the welded sleeve around the exhaust lines and the welded-pipe exhaust radiator in the lower right foreground. The gravity lubricating-oil tank can be seen on a platform in the roof trusses.)

capacity required. But the later tendency has been toward larger units even for the smaller stations. A few large units decreases the size of the building required and also the operating cost, and increases the efficiency of the plant in general. Two or three large units in a station will also receive better care, as a rule, than a large number of small ones. Intermediate capacities are obtained by either slowing down the large engines or running certain units for only a part of the day.

Each main-line station has an auxiliary engine of from 25 to 60 hp. for driving a compressor, oil suction pump, electric generator, fire pump, etc., usually located in one end of the building. Such auxiliaries are mostly belt- or chain-driven from an extension or jackshaft, and are so arranged, where possible, that they can also be driven by the nearest main unit, so that the auxiliary engine can be shut down when the larger engine is running. This helps the efficiency of the station considerably, for small units usually have a rather poor fuel economy and are often very wasteful in lubricating oil. In the larger stations, containing from four to six units, it is the practice to have one or two additional generators, belt- or chain-driven, from other main units in order to have current at all times for lights and for small motor-driven auxiliaries, such as centrifugal water pumps, ice machines, centrifugal oil purifiers, lubricating-oil pumps, shop machinery, etc. On one line recently completed, where there are two 400-hp. engines to each station, an auxiliary 60-hp. engine driving a 50-kw. generator is set between the two engines and another 50-kw. generator is chain-driven from each main unit. In this case all auxiliaries are motor-driven, which makes it an ideal layout. Such a station is shown in Fig. 8.

The larger stations are usually equipped with a machine shop containing a lathe, a drill press, an emery grinder, and a forge, where minor or even quite extensive repairs can be made to the engines on the job. In addition most companies maintain one or two large central shops for making repairs to the heavier parts.

It is almost the universal practice to have the pumps and engines separated by a firewall. For additional safety the air intakes for both the engines and the compressors are carried to the outside of the building. With the semi-Diesel, or hot-plate, type of engine in the earlier installations, a firewall was deemed absolutely necessary due to the open fire required to heat the cylinder heads for starting. With the advent of the full Diesel engines, firewalls were for a time discontinued. But after several very disastrous and costly fires (see Fig. 11), they were again generally adopted. In some cases firewalls were built into stations that had been designed in the meantime without them, which accounts for some of the peculiar arrangements and close clearances to be observed in one or two of the views. Fires have resulted mainly from broken connections on the pump causing oil to spray on the heads of the engines direct, allowing the engine to suck in excess fuel through clearance around the air-intake valve stems or guides, resulting in engine runaways which finally ignited the oil, or from the sprayed oil flowing into conduits and becoming ignited from the hot exhaust pipes of the engine. It is therefore considered that a firewall heavy enough only to act as a shield between pump and engine is sufficient; many of these firewalls are constructed of corrugated sheet iron or metal-lath-reinforced plaster about $2\frac{1}{2}$ in. thick.

Main-line stations are usually in charge of chief engineers, who in some cases report to the mechanical department, but who more often are under the district field superintendents, in which case the mechanical department acts in an advisory capacity. The smaller stations, containing but two units, are usually operated by a lone engineer on each tour. Stations containing four units usually have a crew of one engineer and one oiler on each tour, and in the largest stations containing six or more large units there is usually an extra oiler on each tour and a daylight clean-up man. In the first two cases the crews make their own minor repairs, and a district machinist who covers three or four stations usually aids in making major repairs. In the case of the largest stations, especially while they are required to pump to full capacity, a crew of one machinist and one or two helpers is constantly maintained at each station to make all repairs.

Since pipe lines for obvious reasons shun towns as much as possible, the stations are as a rule in somewhat out-of-the-way and at times very isolated localities; and, as mentioned before, they are usually about forty miles apart. This means that the power plants of each system are scattered over great distances, which makes intensive supervision rather difficult. Much of the operation therefore depends on the chief engineer, who is usually given a rather free hand.

It should also be explained here that in general there is quite a difference between the operation of a pump station and an industrial plant, as far as its status as a power plant is concerned. An industrial plant can, as a rule, be designed for a predetermined load and operated fairly constantly near that load; whereas the load for a pump station is a very uncertain thing which can only be guessed at when the station is under consideration and which may change considerably on very short notice due to general oil-marketing conditions and to the methods of drilling now employed by which the production of an oil pool can be increased from a few thousand barrels per day to its maximum in a few months' time. So pipe-line stations are not only often operated for long periods on an altogether different load than they were designed for, but are usually subjected to wide fluctuations in load from day to day and month to month. Also, when an industrial plant, containing several units, is operated to partial capacity the load on the engines that are running can usually be somewhere near the designed load, whereas on pipe-line stations the load on each engine varies with the number of engines running, for the line capacity is constant. In other words, the pressure on each pump decreases as the units are cut out, so that if one engine of a station containing four units (including a spare) is running, the load on that engine is only about one-third its rated load. It would hardly be good practice to cut out lines simply to obtain a load for the engine, although this has been done in extreme cases. Such conditions therefore would make the unit costs appear altogether out of line as compared to an industrial plant. Furthermore the pressure and number of barrels pumped for a pump load is not a true indication of the horsepower output of the engine similar to the voltage and ampere output of a generator load, for in the former case it is necessary to make several arbitrary assumptions in figuring the horsepower delivered by the engine. Consequently very little attention in general has been paid to the costs per horsepower-hour of the different phases of Diesel-engine operation on pipe lines, and very little information of this nature is available. Such information would also consequently not mean much if it were available, and could not be used in making comparisons with industrial plants. Costs kept on a basis of engine-hours for the year, or per horsepower-year, figuring the rated capacities of the engines for the number of hours operated during a year, divided by the number of hours in a year, would constitute a more logical basis of comparison, or method of expressing such costs for pump stations, if accurate total costs for the same period in question were available in such form that they could be properly apportioned. But here again it must be explained that keeping itemized costs on the many and widely scattered pump stations of a pipe-line system is an altogether different problem from what it is on a single industrial plant, and that such data are consequently also very limited. It should therefore be understood that figures mentioned here in connection with operating and maintenance costs on pump stations are the author's own figures and are only approximations derived from the meager information at hand.

Comparison of Diesel Engines and Steam Engines for Pipe-Line Power

The advantages of the Diesel engine over its immediate predecessor for pipe-line power on Mid-Continent lines are now so obvious that comparisons are almost ancient history. But general comparisons can be drawn that will show the considerations involved in selecting the Diesel engine for the standard form of power and that will bring out the most important points of Diesel-engine installations. The case of Diesel engines being considered to replace existing steam plants, where coal for fuel is to be taken into account, will not be gone into, for this is a very complicated matter involving a study of fixed charges which must be worked out for each individual plant and for changes that might occur in the relative price of coal and oil. But where a new plant of either type of power is considered where oil only is available for fuel, the points involved are first cost, interest, depreciation, dependability, operation, and maintenance, and comparisons can be made roughly as follows:

The first cost of a medium-sized Diesel-engine station of, say, 50,000 to 100,000 bbl. per day capacity is practically the same as that of a modern steam plant of the same capacity with all accessories necessary for good economy, even though a spare unit is included in the case of the Diesel engines. The interest on the investment can therefore also be taken as exactly the same.

From all information at hand, after thirteen years of operation, with the first units installed there is now every indication that the depreciation of the Diesel engine can be assumed to be the same as that of the steam engine itself, and to be less, if anything, than that of the combination of steam engine and boiler equipment.

Dependability is an important item on pipe lines. It is obvious that a pipe line is only as strong as its weakest link. If one station in a chain fails it shuts down the entire line. It was to determine this dependability on 24-hour service that the first trials were made. It has been found that the oil engine needs a little more constant attention and more frequent adjustments. It cannot be overloaded for any great length of time like the steam engine, and should not be forced to operate when in distress; but this is taken care of in the spare unit which is included in the first cost, so it cannot be held against the Diesel engine. With proper attention and intelligent operation it has been found to be just as dependable as the steam engine. The mere fact that all these large systems have been operating successfully on this form of power for almost a decade, speaks for itself.

Operation includes mainly labor, lubricating oil, and fuel oil.

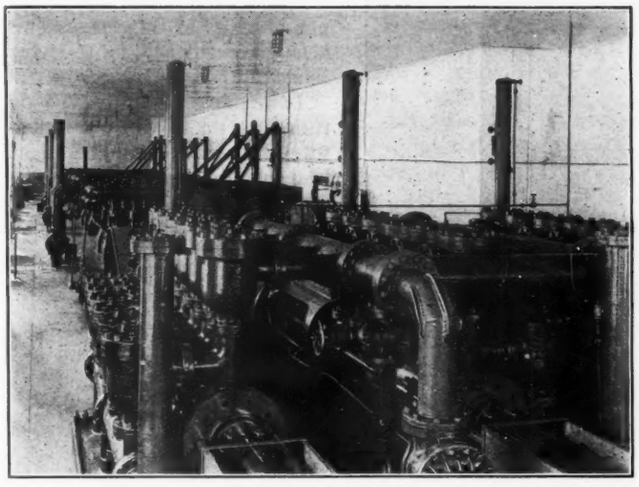

FIG. 7 PUMP ROOM OF THE PRAIRIE PIPE LINE COMPANY'S STATION NEAR CANEY, KAN.

(The second, third, and fourth pumps are the fluid ends of the steam pumps of the original station. In this case the conversion to Diesel-engine drive was made by junking the steam ends of the pumps, reversing the girders, and setting the engines in front of the pumps without disturbing their fluid ends. Other units are additions to the original equipment. The firewall here was installed sometime after the conversion to Diesel-engine drive was made. Note the air chambers on the discharge manifolds of the pump, fitted with gage glasses, and air-charging lines. Also note the welded ell with reinforcing ribs on the discharge line of the pump, in the foreground. Such ells have been used to some extent in an effort to eliminate the numerous breakages that have occurred in cast-iron and cast-steel fittings generally used for this purpose.)

The labor required for a Diesel plant, as previously outlined, compares very favorably with that for a steam-engine plant of the same capacity. The lubricating oil for the cylinders of a Diesel engine must of course be of a little higher quality and therefore of a higher price per gallon than for the steam engine, but the bearing oil in most cases can be the same, and with proper feeding of oil to the cylinders and proper care of the bearing oil in circulation the total cost per horsepower-hour developed can now be assumed to be almost the same as for the steam engine. This leaves only the fuel consumption and maintenance to be considered, and, as previously mentioned, the fuel consumption is about one pound less per horsepower-hour for the Diesel than it is for the steam engine.

But the maintenance is considerably higher on Diesel engines, and since all other items are roughly equal and can therefore be cancelled, the whole matter of comparison can be boiled down to balancing the additional maintenance necessary on the Diesel engines against the fuel saved.

MAINTENANCE

Maintenance is therefore the most important factor to keep in mind in the operation of Diesel engines in pump stations. It can vary considerably for different plants, depending on many things, and can increase to alarming proportions when the best Diesel-engine practice is not strictly adhered to. The problem has therefore been mainly to learn what constitutes the best Diesel-engine practice for this service. Obviously the Diesel engine can receive preference over the steam engine only so long as the maintenance per horsepower-year is less than 25 times the price per barrel of fuel oil, which would be somewhere between $25 and $35 when based on the various values of this product for the last ten years.

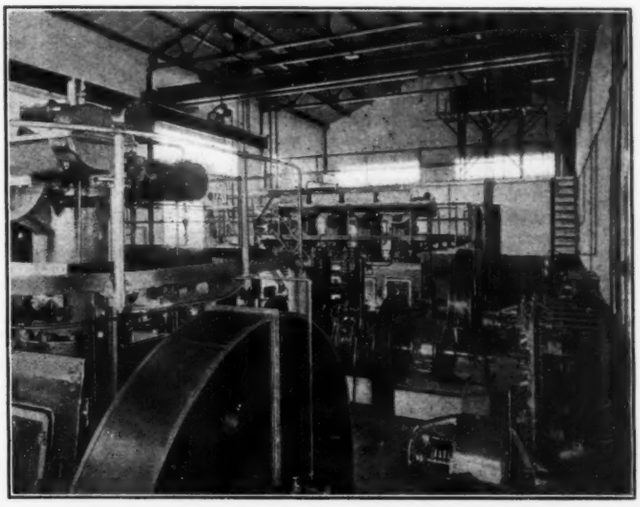

FIG. 8 ENGINE ROOM OF THE OKLAHOMA PIPE LINE COMPANY'S STATION NEAR CROMWELL, OKLA., CONTAINING TWO 400-HP. FOUR-CYLINDER, FOUR-CYCLE ENGINES

(Note the auxiliary engine between the two main units which drives the generator, and the two additional generators driven by the main units. All auxiliaries in this station are motor-driven. Note also the gravity lubricating-oil tank at the upper right corner and the chemical reclaimer underneath it. The overhead tank has two compartments, which allows the oil in one to be cleaned up while the station is operating on the other.)

There is no denying that the maintenance on the earlier installations very nearly approached the first figure given. It was still extremely high as late as five or six years ago. But it is safe to say that now the general average for all companies is well below $5. So the superiority of the Diesel engine for this service has been definitely established. But there is every incentive to still further reduce this item, for every dollar saved in this direction is money made. And since, as far as can be foreseen at the present time, other costs connected with the Diesel engine will remain fairly constant, this is the one item that warrants a good deal of consideration. Nearly all of the improvements that have been made, or are being made, have been contemplated with this end in view. Some of the most important of these comprise reduction of engine load, improved operating conditions, provision of a spare unit, improved cooling-water and lubricating-oil systems, the use of pyrometers or thermometers on exhaust lines, and more careful selection of operators. Better engine design has, of course, also affected maintenance. This is the business of the builder and is too large a subject to cover here, but in passing it should be mentioned that some improvements in this direction have also been accomplished by the pipe-line companies themselves.

LOADING

In the earlier installations it was the rule to load the engines to what was thought to be their full rated capacities. About five or six years ago it became the general practice to relieve the engines of from one-eighth to one-sixth of their load, and most installations since that time have been made on that basis. The load on the engine was assumed to be the hydraulic-horsepower output of the pump plus about 20 per cent for total frictional loses. The hydraulic horsepower is obtained by the well-known formula:

$$\text{Hp.} = 0.00041\ BP$$

where B is the number of barrels pumped per hour, P the pressure recorded in pounds per square inch, and 0.00041 is a constant worked out for the units involved and the specific gravity of average Mid-Continent pipe-line oil. Accordingly a 20,000-bbl. pump working on 725 lb. per sq. in. pressure would require just 300 hp. for driving it, and an engine of 300-hp. rating was the size selected. It is now the practice to use engines of 365 to 400 hp. for pumps of from 22,000 to 23,000 bbl. per day per capacity, and 665 to 750-hp. engines on pumps of about 40,000 bbl. per day capacity, which latter was formerly considered as being about a 600-hp. load. It has been found that this reduction in the load on the engine has decreased maintenance considerably and is well warranted.

This brings up the point that a Diesel engine should be able to carry its full rated capacity when purchased on that basis. This can be answered by saying that the nature of a load must receive some consideration as well as its size. And from information now available it is safe to say that the real load carried in most cases has been more than it was figured.

A pump is a very severe load on a Diesel engine. Unlike a generator, there are several jerks or shocks each revolution, due to the variation of the velocity of the fluid, which is evidenced by the fluctuations of the pressure gage. In addition there are wave shocks set up in the line, or "resurge pressures" as they have been called, which are very much more severe than was generally suspected and which are evidenced by the large number of breakages of fittings and pipe on discharge lines that have occurred since Diesel engines have been used for pump drives. It has often happened that parts tested for as high as 1200 to 1500 lb. pressure have given away under a recorded pressure of 400 or 500 lb., but these breakages were thought to be due to imperfect materials of construction and no allowance for the engine was made for this condition. It should be explained here that when steam pumps were in general use it was not considered necessary to have air chambers on the discharge lines, for the steam did much of the cushioning, and that the practice of leaving off air chambers was carried over into Diesel-engine operation. In the case of the Diesel engine the "punch" of the heavy flywheel acting through reducing gearing is quite a different factor to contend with. It should also be explained that to obtain the maximum flow through a certain amount of pipe line it is often necessary to have the streams of several pumps cut together in the station manifold so that they work on common lines. It is the heavy flywheels and the cutting together of the pumps that has been mainly responsible for these shocks.

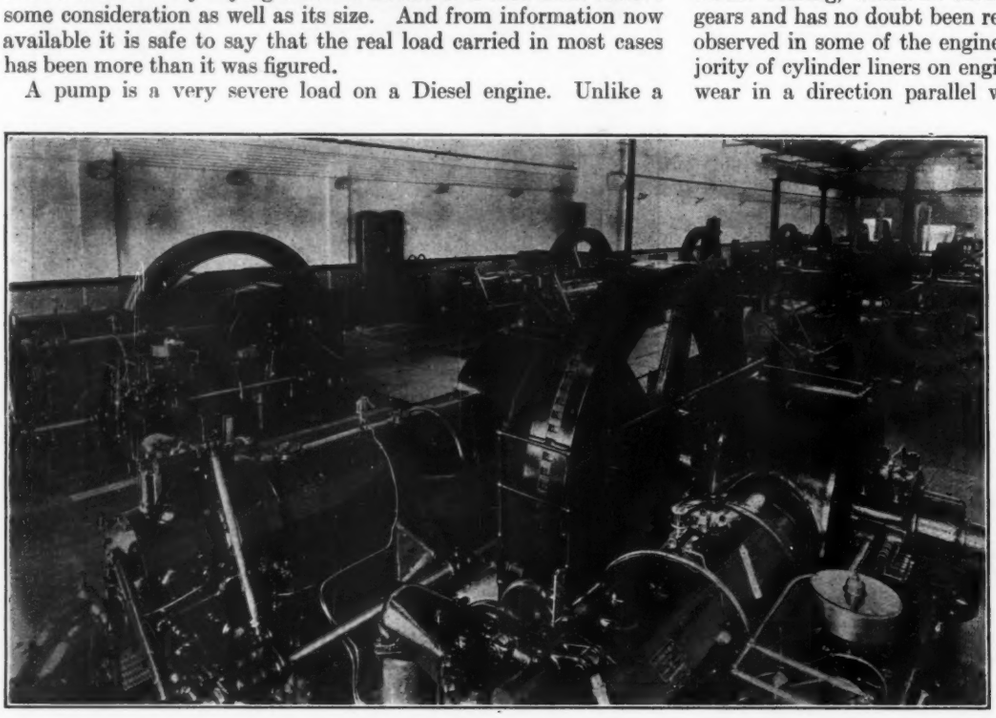

FIG. 9 ENGINE ROOM OF MOORE STATION, NEAR SHREVEPORT, OF THE STANDARD PIPE LINE COMPANY OF LOUISIANA

(Contains four 300-hp. two-cylinder, four-cycle, two 150-hp. one-cylinder, four-cycle, and seven 100-hp. one-cylinder, four-cycle engines. All engines in this station are of the solid-injection type.)

In tests recently made[2] it has been found that there are instantaneous pressures as high as four or five times the recorded pressure, and it is now pretty safe to assume that the average actual pressure is usually higher than the gage shows—points which were not considered in figuring the load on the engine. To improve this condition it is now rather generally conceded that some form of shock absorber is necessary. Spring-and-plunger-type alleviators as shown in Fig. 2 and air chambers charged with air from the engine compressors shown in Fig. 7 have recently been used to some extent for this purpose.

A pump load, in addition to its being jerky, subjects the engine shaft to much lateral strain which is not taken care of by the necessarily large and heavy flexible couplings in general use, which at their best can only be counted on for relieving angular misalignment. This lateral strain is evidenced by excessive wear on the thrust bearing, which in turn causes excessive wear on governor gears and has no doubt been responsible for the peculiar liner wear observed in some of the engines. It has been found that the majority of cylinder liners on engines of a certain pipe line show more wear in a direction parallel with the piston pin than crosswise. This condition applies to horizontal as well as vertical engines. To remedy excessive governor-gear wear in one case all the main bearings of the engine have been made into thrust bearings, and to help the liner wear, the piston-pin bearings in some cases have been given from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. side clearance.

These facts regarding the nature of the pump load will explain why the reduction in the engine load has been entirely justifiable up to the present time. When these points have been given more thorough study and the necessary remedies have been generally applied, there is every reason to believe that the engines can eventually be put back on full load again.

OPERATING CONDITIONS

Due to lack of intensive supervision on widely scattered plants, and to making such an extensive and radical change in the type of power in so short a time, the operating conditions in most cases left much to be wished for at first, which was to be expected to a certain extent. The rating of a Diesel engine is based on ideal conditions. Any neglect, such as improper lubrication, scales in the jackets, leaky valves, choked spray nozzles, uneven load on the cylinders, or any misadjustment, immediately affects the ability of the engine to carry its load, especially on 24-hour service, a fact which was not given proper consideration. Neglect of the steam engine usually resulted mainly in decreased efficiency of the plant, but neglect of the Diesel engine as a rule means increased maintenance. Some of the neglect was due to carrying over, to some extent, steam-engine principles in operation. But operating conditions have improved steadily, which has helped maintenance considerably. To insure periodic attention to all parts of the engine, one company now has in force a system of daily log sheets which are kept up by the chief engineers. These log sheets cover all important parts of the engine. Repairs made, measurements taken, parts cleaned, and conditions found during inspection of the engines are noted for each engine at each station. A monthly summary of all daily sheets is sent into the main office, where a check can be made on the care that each engine has received during the month. Another company has in force a periodic checking of

[2] See paper by Nelson B. Delevan: An Investigation into the Cause of Breakages in Crude Oil Pipe Line Transportation Systems, read before the American Institute of Mining and Metallurgical Engineers, February, 1926.

crankshaft, etc., by machinists, who send in the information on specially prepared blanks. In addition the engineers in charge have learned that periodic inspection and more thorough daily attention save them much work on repairs in the long run.

THE SPARE UNIT

It was not considered necessary at first to have a spare unit, and engines were often required to run while in distress. It has been the practice for some time to provide a spare unit in all stations. This has helped maintenance considerably in allowing an engine to be shut down whenever necessary before any great damage has been done, and in making it possible to more thoroughly inspect, adjust, and clean all engines periodically.

OPERATORS

It was the practice at first to use the former steam engineers for the new Diesel-engine stations. In general these made rather poor oil-engine operators, due to their tendency to apply to the new form of power principles practiced on the old. The later tendency has been to use either machinists who have had a good deal of experience in repairing Diesel engines, or exceptionally able tour engineers from the older stations, for chief engineers for new Diesel-engine plants. It requires very careful picking of men to obtain a good chief engineer, for in addition to being thoroughly familiar with the engines he must be able to handle men and to solve problems that affect costs and efficiency. The general realization that chief engineers must be of a little higher type than was at first considered necessary, has improved conditions a good deal.

COOLING-WATER SYSTEMS

In the Mid-Continent area where water is, as a rule, either very scaly or highly corrosive and often fairly scarce, the Diesel engine was welcomed as a way of eliminating the trouble experienced with

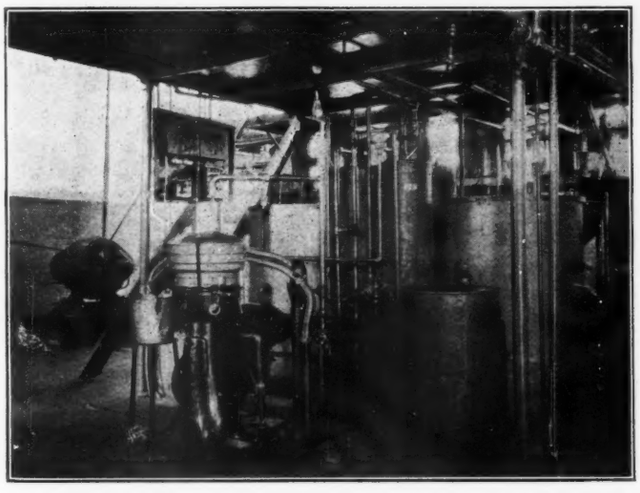

FIG. 10 TYPICAL LAYOUT OF LUBRICATING-OIL HEATERS AND FILTERS FOR TWO OF THE ENGINES AND A CENTRIFUGAL PURIFIER WHICH WORKS CONTINUOUSLY ON THE OVERHEAD LUBRICATING-OIL TANK COMMON TO ALL ENGINES ON A PRAIRIE PIPE LINE PUMP STATION

boilers. It is a fact of course that the Diesel-engine plant requires much less water to operate on than a boiler plant of the same size, and that bad water does not entail the trouble, expense, or danger when used for cooling water in Diesel-engine jackets that it does when used in boilers. There was consequently very little thought given to water problems at first. Cooling-water systems have been mainly of the open gravity surface-cooling type, and until recently raw water and earthen reservoirs were the rule. The result was an accumulation of mud and scale in the jackets, which necessitated frequent washing out of the mud and periodic reduction of the scale with acid. If the cleaning of the engine was neglected it increased maintenance in several ways, and even if the cleaning of the jackets was done religiously the engine was affected to a greater or less degree between cleanings. It is now almost the universal practice to provide concrete reservoirs at all main-line stations, which has eliminated the mud, and several companies are now using some sort of water treatment to remove the scale-forming elements before the water is put into the system. To treat the water chemically is of course an operating expense, but the lack of such treatment usually results in a maintenance charge in the nature of broken cylinder heads, seized pistons, or burnt-out piston-pin bearings. Furthermore the expense of treatment is a good deal less in most cases than the cost of the acid and the labor required for periodic cleaning, so it is well warranted.

LUBRICATING-OIL SYSTEMS

A considerable reduction in maintenance has been effected by improved lubricating-oil systems. It was at first generally believed that the old steam-engine filter, usually recommended and furnished by the engine builders, would be sufficient for keeping the bearing oil in good condition, and that the fine particles of carbon collected by the oil were, if anything, a help to lubrication. The old steam-engine filter was a strainer at its best, which allowed the oil to become more and more saturated with carbon and did not remove the water present to a greater or less degree in all

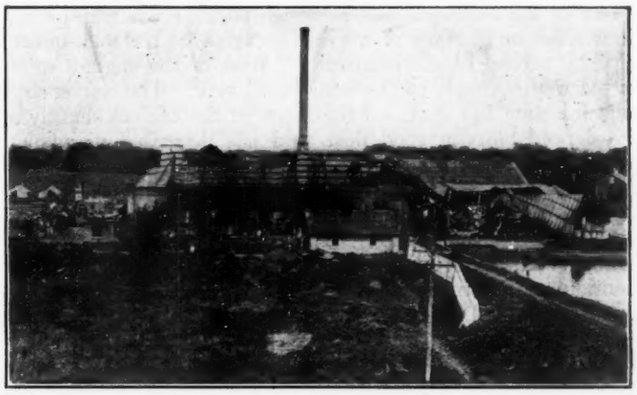

FIG. 11 THE RESULT IN ONE CASE OF NOT HAVING A FIREWALL BETWEEN THE ENGINES AND PUMPS

lubricating-oil systems regardless of whether there are water-cooled pistons to contend with or not. This usually resulted in the feeds becoming undependable and in excess oil being fed to all points for safety's sake. It also resulted in excessive bearing wear, for it has been found that the carbon particles made a rather good grinding compound. When the oil became extremely dirty it was the practice to treat a batch of 50 gal. or so at a time in chemical reclaimers and return it to the system, but in most cases proper heat for the reclaimer, to get the best results, could not be obtained, for the water from the engine jackets—at a maximum of 140 or 150 deg.—was usually used to run through the reclaimers. The later practice has been to keep the oil in a much cleaner condition at all times. This has been accomplished in several different ways. On one line a centrifugal separator has been installed for each engine, which cleans up the oil as it leaves the engine and before it is returned to the overhead tank for recirculation. On another line a very elaborate lubricating system has been developed, where the oil from the engines is settled and partially cleaned as it flows through heaters and remodeled filters before it is returned to the overhead tank, and where it is more thoroughly cleaned and dehydrated by a centrifugal purifier which is constantly working on the oil in the overhead tank. All the oil in the system, in this case, is kept hot, which keeps the lines well scoured at all times, and a cooler is provided for cooling the stream of oil before it goes to the engines. The heat in this case is obtained by hot water circulated through sleeves welded around the exhaust lines, so that temperatures near the boiling point can be obtained. On other lines cleaner oil has been obtained, either by having a much larger quantity of oil in the system than formerly and providing large settling compartments which give the oil a chance to rest and settle on its trip around, but which necessitate periodic cleaning of the whole system, or by having double overhead tanks so that all the oil in one tank can be thoroughly cleaned in chemical reclaimers or centrifugal purifiers while the station is operating on the other tank. The crosshead type of vertical engine with an arrangement

for catching the drip oil from the pistons separately and keeping it out of the crankcase has aided considerably in making it possible to keep the system in a much cleaner condition. Cleaner oil has resulted in very much reduced bearing wear, which not only affects maintenance but reduces operating cost.

PYROMETERS AND THERMOMETERS

When one cylinder of a multi-cylinder engine is not carrying its share of the load, it of course throws that load on the remaining cylinders, which may result in their carrying an overload and which will mean of course high maintenance in spite of the fact that the engine as a whole is of ample capacity. This condition is not always apparent to the operator. To enable the operator to check each engine hourly and keep the load balanced on all cylinders, several of the companies have adopted the use of pyrometers or special mercury thermometers for indicating the temperature of the exhaust gases coming from each cylinder; this has helped the engines so equipped considerably.

SOLID-INJECTION ENGINES

One of the improvements in design which bears mentioning is the conversion of many of the earlier engines to the solid-injection type by several of the companies. Most of the engines so converted were formerly of the semi-Diesel type. The conversion to solid injection has increased the power of the engines slightly and the dependability a good deal, and has decreased maintenance considerably by doing away with the compressors.

FURTHER COMPARISONS

In making the comparisons between steam and oil-engine power nothing was said of the item of safety, which, however, is worth mentioning. In general the operation of the Diesel engine does not carry the element of danger that lies in a steam boiler. Neglect of a Diesel-engine plant due to an operator's falling asleep or to any other cause may mean some expense, but it can hardly result in the loss of human life like the similar neglect of a boiler plant. This was more of a factor to be considered, however, when the 12-hour day was the common practice on pipe-line-station operation.

There was also nothing said in these comparisons about the point that in spite of the fact that the fuel consumption is but one-third that of the steam engine there is still a great deal of heat available in the exhaust gases of the Diesel engine which can be turned into power or made use of for heating purposes and which should go to the credit of the Diesel engine. Of the 8000 to 9000 B.t.u. per hp-hr. consumed by the engine, some 2500 are given back in the exhaust. With large surface heaters a good 40 per cent of the exhaust heat could be reclaimed. This amounts to about 1600 B.t.u. per hp-hr. or a possible one-sixth of the original amount consumed, which should be considered in drawing comparisons. To the author's knowledge nothing has been done so far on pipe-line stations to turn this into power, but there has been some use made of it for heating purposes. In one case exhaust gases have been passed directly through tube heaters, or heat exchangers, through which the lubricating oil is circulated before going to the centrifugal purifiers. In another case, as previously mentioned, water circulated through pipe sleeves welded around the exhaust lines is used for heating the fuel oil, lubricating oil, and the station office. Some 500 B.t.u. per hp-hr. are obtained in this way. In addition the exhaust gases are passed directly through welded-pipe radiators installed in the engine room, from which enough heat is ordinarily obtained to heat the building proper. This has eliminated the necessity for any steam equipment at such stations, which is quite an item. All of this heat is obtained at the cost of interest only on a very nominal investment. Installations of both of the last-mentioned types can be seen in Figs. 5 and 6.

Fuel Oil for Railways

By J. C. MARTIN, JR.,[1] SAN FRANCISCO, CAL.

THIS paper will not deal with the efficiencies possible of attainment or being daily attained in locomotive practice by the use of oil as fuel,[2] but will point out the reasons that economically warrant the continuance of its use on railways, even to the extent, if it may be anticipated, of its allotment for use in locomotive fireboxes for steam-generating purposes should its conservation in the future become a national issue.

What we are concerned with most now is the *future* use of fuel oil for railways, as all those in contact with railroad operation are fully cognizant of its present use and advantages.

The following remarks are based on the premise that the peculiar conditions surrounding an oil-burning locomotive justify, and in fact demand, its adoption and use wherever fuel oil can be supplied in locomotive tenders at a B.t.u. value equivalent to that of coal, owing to the unusual efficiencies possible to obtain in the exacting service of a carrier, as hereinafter pointed out.

Fuel oil, owing to its relatively greater B.t.u. value per unit volume, effects on an average on our trunk lines burning oil a saving of approximately 30 per cent over coal in the tons of fuel actually required to be transported for locomotive steam-generating purposes.

Fuel oil can be transported through pipe lines, eliminating the necessity of utilizing railway equipment for the transportation of fuel to be burned in locomotive fireboxes, making available such equipment for other purposes while effecting a material fuel saving in the tractive effort required to haul locomotive fuel. One-third of the railroad's tonnage consists of coal, coke, and their by-products, while 30 per cent of the total freight tonnage of the railroads is bituminous coal, and of all coal mined 27.9 per cent is used on the railroads as fuel. These statistics are taken from an article by J. D. Battle, traffic manager of the National Coal Association, in the Proceedings of the International Railway Fuel Association of 1925.

Refinery residuum, our present fuel oil in a locomotive tender, is practically free from moisture and has a fixed-carbon content of approximately 85 per cent. The burning of such a fuel in a locomotive firebox combustion chamber means, with averagely good furnace construction and reasonably efficient burner and firing equipment, that ideal conditions obtain for maximum firebox and boiler efficiency. Through the perfect control of this constantly fed fuel of high fixed-carbon value it is possible for a locomotive fireman of fair intelligence to continuously maintain boiler pressure within three to five pounds of the point at which the pop valves are set without undue physical exertion, even on the largest modern steam-locomotive power unit in existence and under the ever-varying or intermittent load which is at peak one minute and at the next minute, as when the locomotive pitches over the grade under drifting condition, is at a minimum.

The remarkable control of the fire in an oil-burning locomotive is exemplified in practical operation by the fact that the damper control needed in coal firing for the protection of the superheater units when steam is practically shut off and engine is drifting, is now being entirely eliminated, the units, however, being maintained in perfect condition. The explanation of this is that in a coal-burning locomotive the fireman in meeting the heavy drag on the engine is required to keep a maximum fire on the grate bars. When the peak is reached and the engineer shuts off steam, the heavy fire is still present. The damper control, functioning as it does with the locomotive throttle in accordance with the universal practice in coal-burning superheater locomotives, is positively necessary to keep the superheater units without steam in them from burning by cutting off the draft that would otherwise carry the fire about the units.

In an oil-burning engine, when steam is shut off the fireman immediately cuts down his fire to a minimum, and, there being no fire of any consequence to pull through the superheater tubes, these units when without steam are consequently automatically protected. In practice this means that in an oil-burning engine there can be at all times a free and unobstructed passage for the hot furnace gases through the superheater tubes and around the units without damaging them, and that the diaphragm plate, baffle, and damper with its operating mechanism, as well as its original expense and cost of maintenance in service, can be entirely done away with.

This makes freer-steaming engines and equalizes the expansion and contraction on the tube sheet at the firebox end, as all of the tubes, including the smaller saturated-steam tubes and the larger superheater unit tubes, have heat or fire through them at all times; and some four years of actual practice, during which time a large number of oil-burning locomotives have been freed of their damper-control mechanism, have shown that tube sheets give very much longer service without cracking than when only a part of the tubes in the flue sheet, as in the case of damper control, are at times working. Again, the fact that they are unobstructed practically eliminates the necessity of blowing out superheater tubes that are now commonly plugged with carbonaceous matter, a distinct saving and advantage in turning engines, and making possible the immediate inspection of the superheater units at all times.

Keeping the boiler pressure of a coal-burning locomotive continuously within three to five pounds of the point at which its pop valves are set is practically impossible with hand firing, because mere man is physically unable to fire and spread coal at the rate of, say, 120 lb. of coal per square foot of grate area per hour, let alone the higher rates approximating 175 lb. now employed on the larger types of steam locomotive power units in general operation.

The mechanical-stoker equipment necessary for such rates of firing, even though efficiently designed, cannot effect the economies obtainable with fuel oil under the peculiar conditions of a locomotive in which the constant pull of the exhaust nozzle or draft through the fuel bed causes holes in the fire that cannot be individually recognized by any stoker and covered; consequently the maintenance of a high uniform boiler pressure comparable with that obtainable by burning oil is a very difficult thing to establish. Stated in a few words, these unavoidable conditions obtaining in a locomotive burning coal are wholly absent in a locomotive burning fuel oil.

By keeping the locomotive up to its maximum ability to do work, for which its boiler is directly accountable in maintaining continuously a maximum steam pressure, the average oil-burning locomotive on a majority of the trunk lines using fuel oil shows an increase of 15 per cent in tractive effort over the same engine burning coal.

Through this greater sustained tractive effort a greater tonnage movement can be effected with the same number of locomotives, which, taken together with the fact that the steaming radius of a locomotive is materially increased through elimination of delays at terminals in refueling, cleaning of fires, and quicker turning of engines, makes for an efficiency in transportation not obtainable in a steam-generating locomotive power unit except by the use of fuel oil in its firebox combustion chamber.

The elimination of spontaneous combustion and deterioration of fuel in storage are two important factors to be considered in the adoption of fuel oil for railroad use.

These facts show clearly *why* fuel oil should continue to be used in locomotives. As to *when* it should be used, two factors will determine, the first being the matter of its transportation cost. In this, actual figures from well-operated oil-burning railroads show that when fuel oil in locomotive tenders costs on the average

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[2] For statistical information relative to the performance of fuel oil in locomotive fireboxes, see paper by W. H. Bohnstengel, on Oil-Burning Practice on Locomotives with Resulting Fuel Performance, in the Proceedings of the International Railway Fuel Association of 1920, which deals with the present-day method of firing and use of fuel oil, and which is both illustrative and descriptive; also paper by J. M. Johnston on the Burning of Fuel Oil in Railroad Locomotives, presented at the American Petroleum Institute Meeting of 1923.

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not over 15 per cent more than coal, figuring $3^1/_2$ barrels of oil per ton of coal, it is the most economical fuel to use. Second, the fuel resources of the section in which a railway operates will dictate very largely what fuel will be used. For example, in California we have no coal of steaming ability in volume sufficient to meet the needs of our large railway systems, that available being principally of the lignite type and of low B.t.u. value, which is unsuited for the high rates of firing encountered in a locomotive-firebox combustion chamber, and such fuels with their many problems of transportation and storage along the right of way, not to mention the storage in the locomotive tender itself, do not spell success in effecting continuous and efficient movement of tonnage.

The only commodity a railway has to sell is transportation, and the expeditious and economical movement of its freight and passenger traffic is just as important to the public as it is to the railway.

As to the future supply of fuel oil available for railways, the author would refer to an article on The Railway Problems of the Pacific Coast which he read before the San Francisco Chapter of the A.S.M.E. in 1922, since the remarks made therein are equally applicable to the railway fuel-oil problem as a whole, and the predictions made then that the supply of fuel oil would keep pace with the demand for railway use for many years to come are just as pertinent today. Of course right now the supply is far ahead of the demand, in view of the very much greater amount of crude oil in storage than in 1922, while not more than 500 additional locomotives have been equipped to burn fuel oil since that time.

Now, with a general knowledge of the economies inherent in an oil-burning locomotive not possible to obtain with one burning coal, we can all talk with understanding as to why the use of oil on railways should take precedence—and, in fact, realize why oil has an equitable right in the service of a carrier—over its use in stationary furnaces, in which latter the natural-draft conditions and relatively constant loads make it possible, through good furnace design, to obtain approximately the same efficiencies in a combustion chamber burning coal as in one burning fuel oil.

In conclusion, the coöperation and support of the members of The American Society of Mechanical Engineers are earnestly requested in impressing all those persons, commissions, or bodies whose duties may bring them in contact with the use or allotment of fuel oil, or legislation affecting it, with the urgency of utilizing this fuel to the last degree in the service of the carriers, adopting the slogan, "Keep Fuel Oil for the Railways."

Mechanical Engineering in the Cracking, Heating, and Cooling of Oil

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The most important development in the last few years in the petroleum industry is unquestionably the method of refining or cracking heavy oils into lighter hydrocarbons. With most processes the cracking of oil occurs at pressures of 600 lb. and above, and temperatures as high as 900 deg. fahr. or higher, and the industry is becoming more than ever dependent upon mechanical engineers to design the apparatus for these pressures and temperatures.

The paper deals with the combustion and furnace design of pipe stills and suggests arrangements that will increase their efficiency. The importance of a knowledge of individual heat-transfer resistances between gases and tubes as well as oil and tubes is pointed out. Data for the heat transmission in each individual case is given also for heat transmission between oil and the tubes in heat exchangers.

The frictional losses in oil flowing through tubes are briefly discussed, and a table is given which shows the frictional loss or pressure drop for different sizes of tubes and different oil velocities and viscosities.

Illustrations and descriptions of newly developed joints between tubes and return headers of pipe stills are shown, and desirable arrangements of the tubes are discussed; also various arrangements of heat exchangers.

THE most important development in the last few years in the petroleum industry is unquestionably the commercial application of methods of cracking heavy oils into lighter hydrocarbons. In most processes the cracking of oil occurs at high pressures and high temperatures—of the order of 600 lb. and more for the former and 900 deg. fahr. and more for the latter.

The design of apparatus for these pressures and temperatures is essentially a problem for mechanical engineers. Thus far the industry seems to have applied comparatively little mechanical engineering in the solution of these problems. Formerly oil stills were ordered from any tank maker, without giving serious consideration to the engineering problems involved. It is only very recently that the refinery man has awakened to a recognition of the fact that mechanical engineering can be of considerable assistance to him. It is only within the last few years that the pipe still has been commercially developed, and only quite recently that bubble towers have been applied on an extensive scale with great success, although such towers had been used for many years in other industries.

The present paper represents an attempt to cover some of the essential fields of application of mechanical engineering in the cracking, heating, and cooling of oil, particularly the mechanical design and performance of pipe stills and heat exchangers.

Combustion and Furnace Design of Pipe Stills

The operating conditions of a furnace for a pipe still are distinctly different from those of a furnace where heat is generated with the purpose of heating or evaporating any other liquid than oil. For instance, the furnace of a steam boiler should be operated at the highest temperature permissible for the refractories, or at temperatures considerably above 2000 deg. fahr. In a pipe still the hot gases reaching the oil tubes should not be higher than 1500 to 1800 deg. fahr., depending upon the processes used and the kind of oil passing through the tubes. Steam boilers in practically all cases are provided with baffles which divide the gas path into many passes. In a pipe still, any concentration of heat at any one part of a tube should be avoided. Therefore the gases should be as uniformly distributed as possible over the entire length of the tubes. These two requirements have considerable influence upon the design of furnaces for pipe stills.

Other means than high gas temperatures must be sought to obtain high efficiencies. The combustion space or furnace volume and the fuel-burning devices must be so arranged as to meet the above requirements.

In most cases pipe stills are fired with oil. Often the gas formed while oil is being cracked, the so-called "fixed gas," is utilized in the furnace in addition to fuel oil. The two important features of design for oil-fired furnaces are volume and method of introducing the fuel, and air or furnace arrangement and selection of burner. In the construction of the furnace it is very important to utilize every available cubic foot of space as combustion space.

Both types of burners can be used in pipe stills successfully; the steam or air atomizing burner and the mechanical or oil-pressure burner. Steam atomizing burners are often used, and reasonably good efficiencies are obtained. The original installation is less expensive, and no high-pressure pumps are required. It seems, however, that the following advantages of the mechanical burner are very well established:

1. Saving in steam as compared with steam atomizing burners
2. Better regulation
3. Less trouble from tip stoppage
4. Less maintenance cost for burners
5. What is, however, of most important consideration for pipe stills, is that the flame from mechanical atomizers is less intense, fills the furnace more completely with a soft, low-velocity flame, and does less damage to brickwork.

More satisfactory results are obtained with oil-burning equipment when the burner used is designed to give a graduated flame and equal efficiency for different quantities of oil burned. It seems that this qualification applies more to mechanical burners than to steam or compressed-air atomizing burners.

After the oil supply is regulated to carry the load, the air supply should be so adjusted to give a yellow billowing flame in the furnace and a slight haze of smoke from the chimney, this being a rough means of judging efficient combustion. Too much air results in a short dazzling-white flame similar to a tungsten electric lamp, and gives a perfectly clear chimney.

The author has seen a number of pipe stills where the flame was too near to the tubes. It is always advantageous to provide a long travel to insure complete mixing of the products of combustion before they reach the oil tubes.

In order to distribute the flame better over the entire furnace, it is more advisable in connection with pipe stills to have more smaller burners than fewer large ones.

The furnace volume required for the complete combustion of any fuel is a function of many variables, among the more important of which may be mentioned the chemical composition of the fuel, the type of fuel-burning equipment used, the shape of the combustion chamber, and the means provided for mixing the fuel and air in the furnace. In general, on account of its chemical composition and physical state, fuel oil when burned in modern mechanical atomizing burners requires less volume than any other fuel. In pipe stills, however, due to the fact that any concentration of the flame is to be avoided, liberal furnace volume should be provided. It is good practice to allow between 3 and 5 cu. ft. per gallon of oil to be burned per hour, or between 15 and 20 cu. ft. for every 100 sq. ft. of the outside surface of bare oil-heating tubes, and from 8 to 12 cu. ft. for every 100 sq. ft. of outside surface of the so-called "extended surface."

Furnace Walls

In spite of the fact that in pipe-still furnaces high temperatures are not desirable, due attention should be given to the wall construction. A perfect furnace wall would be one which under all conditions of service remains impervious to the flow of gas or air, does not crack, spall, or soften, and does not become easily injured by occasional impingement of the flame. It is well known that our

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furnace walls fail to meet the above requirements fully, and we may profitably consider briefly some of the reasons for the shortcomings of the pipe-still walls, and some of the ways by which they may be overcome. Examining the characteristics of refractory materials, it would seem that an almost ideal combination of materials could be selected, and if money were no object, the construction of good furnace walls would be greatly simplified. Unfortunately, however, the cost of some of the more desirable materials is such as to prohibit their use except in small quantities for special purposes. Usually the weakest part of a wall is the joining material for the firebrick. Fireclay of approximately the same composition as the brick has been found to be the most satisfactory material with which to bond the wall. It is always advisable that firebrick be obtained with as close uniformity in dimensions as possible, so that the amount of joining material may be reduced to a minimum.

Fireclay brick begins to soften at 600 to 800 deg. fahr. below its melting point. With low settings this is not important, because the surface exposed to high temperature is small and the superimposed loads light. However, for larger pipe stills with adequate furnace volume for proper combustion, this characteristic of firebrick must be given due consideration. An effective remedy is the air-cooled wall. Many refinery engineers are of the opinion that because high temperatures are not desirable in pipe-still furnaces, preheated air would be of no value—in fact, that it is rather a menace. This is entirely contrary to facts. The lower the efficiency of a furnace and the lower the furnace temperatures, the more benefit will be derived or the more fuel will be saved by preheating the air.

Fig. 1 gives a graphic representation of the efficiency of a pipe still and also shows the separate losses for different furnace temperatures or different percentages of CO_2. It is based on 60 deg. fahr. for air entering the furnace and on 600 deg. fahr. exit-gas temperature.

Part of the heat produced is lost in the flue gases passing through the stack. In order to account for this loss we must know the temperature of the exhaust gas, the heating value, and volume—and consequently the analysis of the fuel and gases—as well as the amount of the excess air or surplus air. This loss is represented in the illustration as area q_1.

Some heat is lost due to the moisture from burning of hydrogen, which moisture is evaporated and passes with the flue gas through the stack. The latent heat of the vapor is a direct loss. It is represented in the illustration as area q_2.

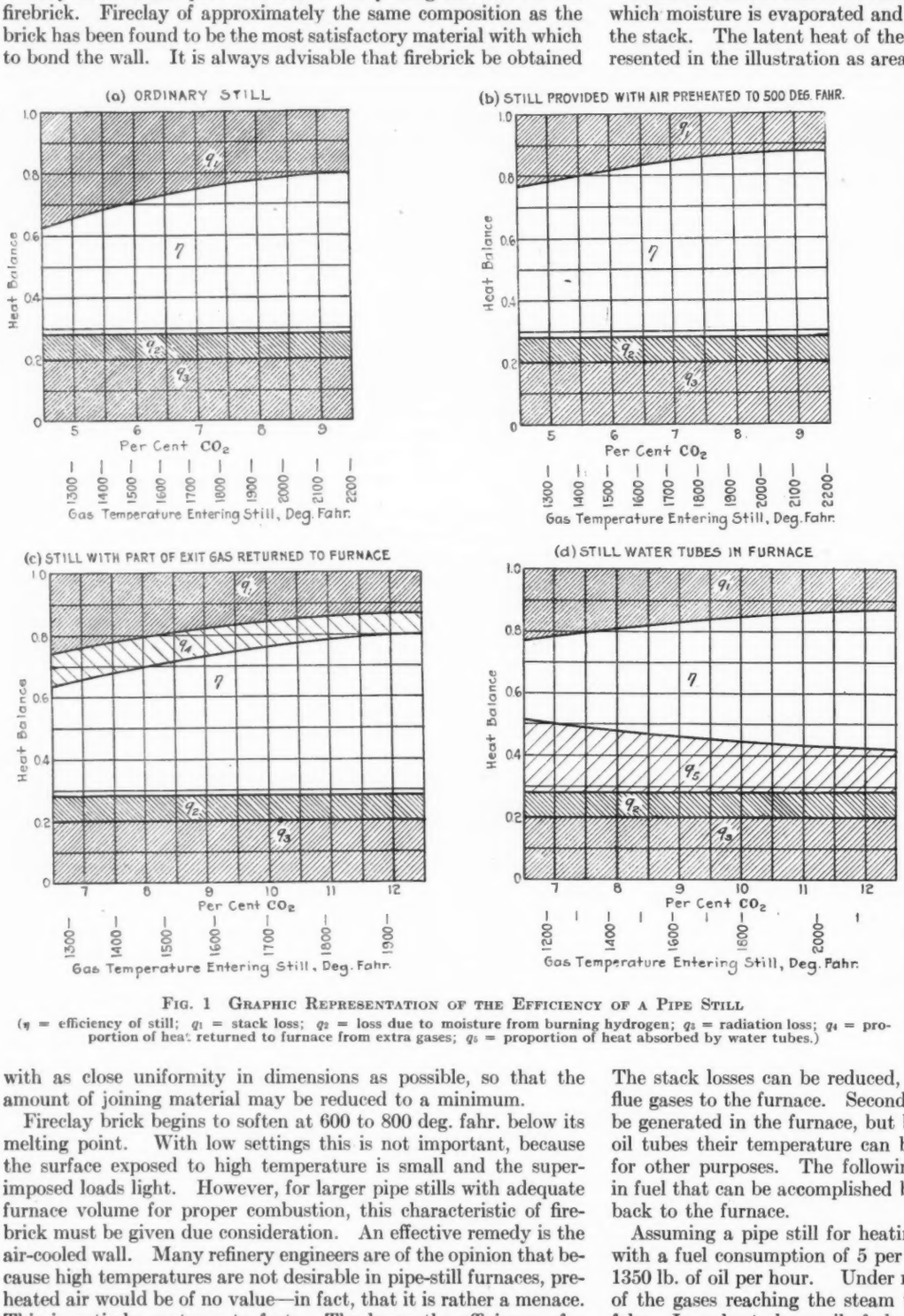

FIG. 1 GRAPHIC REPRESENTATION OF THE EFFICIENCY OF A PIPE STILL
(η = efficiency of still; q_1 = stack loss; q_2 = loss due to moisture from burning hydrogen; q_3 = radiation loss; q_4 = proportion of heat returned to furnace from extra gases; q_5 = proportion of heat absorbed by water tubes.)

Part of the heat is also lost through radiation from the hot furnace walls and roof. This loss is very difficult, if at all possible, to determine directly. It can be found only by very careful tests and computations of heat balances. This loss is designated by the area q_3.

The area η represents the heat utilized or imparted to the oil. Depending upon the temperature of the flue gases, it varies from 35 to 60 per cent of the total heat of the fuel burned. The efficiency, or the percentage of the total heat of the fuel utilized, depends also upon the cleanliness of the tubes inside and outside, upon the relation between the amount of gases and the amount of heating surface passed by them, and upon the arrangement of the heating surface. The more heating surface passed over by the gases and the more intimate the contact between the gases and the heating surface, the more the heat absorbed from the gases, the lower the exit-gas temperatures, and the more the heat of the fuel utilized for heating the oil.

At a comparatively low temperature in the furnace, or between 1400 to 1800 deg. fahr., a maximum efficiency of 50 per cent will be obtained. In other words, only a half of the heat available in the fuel is utilized. Fortunately there are two ways of increasing the efficiency of a pipe still, but these are arrived at from different directions. The stack losses can be reduced, first, by returning a part of the flue gases to the furnace. Second, gases of higher temperature can be generated in the furnace, but before coming in contact with the oil tubes their temperature can be reduced by utilizing their heat for other purposes. The following example will show the saving in fuel that can be accomplished by turning some of the exit gases back to the furnace.

Assuming a pipe still for heating or cracking 2000 bbl. per day with a fuel consumption of 5 per cent or 100 bbl. a day, or about 1350 lb. of oil per hour. Under normal operation the temperature of the gases reaching the steam tubes will not be over 1500 deg. fahr. In order to burn oil of about 18,000 B.t.u. per lb. and have the resulting gases at a temperature of 1500 deg. fahr. with 85 per cent furnace efficiency, it is necessary to have 45 lb. of gases per pound of oil or 200 per cent of excess air, with a resulting efficiency of the still of 40 to 50 per cent. The lower efficiency is due to the

fact that the 200 per cent of excess air which is used has to be heated from atmospheric temperature to 1500 deg. fahr. However, only a part of the heat can be utilized in the still as the flue gases leave the tubes with a temperature of about 700 deg. fahr., containing nearly half of the heat.

When the 1350 lb. of oil is burned with 200 per cent of excess air, approximately 6100 lb. of gases will result, and, as already mentioned above, at a temperature of 1500 deg. fahr. Assuming that 35 per cent of the flue gases can be returned to the furnace at a temperature of 700 deg. fahr., the other 65 per cent of the flue gases will have to be at a temperature of 1950 deg. fahr. in order to have the same amount of gases at 1500 deg. fahr. To bring this 65 per cent of gases to the temperature mentioned, however, only 1080 lb. of oil will be required. In other words, with this proposed arrangement there will be the same amount (6100 lb.) of gases at a temperature of 1500 deg. fahr. at the entrance of the still, but only 1080 lb. of oil will have to be burned, which means a saving of 270 lb. per hour, or 19½ per cent. With the present price of fuel a saving of 19½ per cent should be a very attractive proposition, even for oil refineries. As a matter of fact, the saving may be slightly more, due to the higher furnace temperature and more favorable conditions for combustion of the fuel.

Another advantage is claimed for this arrangement. From experience with pipe stills we know that the tubes which burn out first are those located nearer to the furnace walls, as they receive heat from the furnace as well as radiant heat from the brickwork. At least a part of the returning gases could be introduced into the furnace near those tubes, and would to a certain extent cool them. While this could also be done in a regular furnace, it would, however, reduce the efficiency. Besides, no operator would like to have cool air introduced directly below the steam tubes.

In every refinery great quantities of steam are required, and this is usually generated in one or more boiler houses and thence distributed to the places of use. In some cases steam has to be conducted for a considerable distance from the boiler house to the steam stills. The efficiency of a pipe still could be increased considerably if the fuel could be burned in the furnace with a low percentage of excess air and a resulting high temperature of the flue gases, but in order to reduce the temperature before entering the oil tubes, one or more rows of water tubes could be installed and the steam generated in these tubes.

Assuming the same example as before: If 6100 lb. of gases per hour are generated in the furnace at a temperature of 2000 deg. fahr., 1500 lb. of oil will have to be burned in the furnace. If the water tubes cool the gases 500 deg., the latter will enter the pipe still as in the previous example with a temperature of 1500 deg. fahr., leaving the tubes at 700 deg. fahr., with the gases cooled from 2000 down to 700 deg. fahr.; and with a furnace efficiency of 85 per cent as before, the total efficiency of the oil and water tubes will be 72 per cent instead of 50 per cent where the gases are generated directly in the furnace with a temperature of 1500 deg. fahr. Taking into consideration, however, the fuel which would be required to generate the same amount of steam in the boiler house, it will be noted that a much better utilization of the heat available in the fuel is accomplished.

Fig. 1-*b* is a graphic representation of the efficiency of a pipe still similar to Fig. 1-*a*, but with the air for combustion preheated to 500 deg., either in the brick wall or by a separate air heater utilizing the heat of the escaping flue gases.

Fig. 1-*c* shows the efficiency of a pipe still with 35 per cent of the exit gases returned to the furnace, while Fig. 1-*d* represents the efficiency where water tubes are placed in the furnace ahead of the oil tubes.

Area q_4 indicates the increase of efficiency due to the returning of the flue gases, and area q_5 that due to the water tubes.

Another and better method of utilizing the heat of the fuel with a comparatively low furnace temperature would be to absorb as much heat as possible by radiation. While advantage is taken of this method in steam boilers, experience has shown that it is not advisable to subject oil tubes directly to the flame of the furnace. In more recent years a furnace design has been proposed which makes it possible to take advantage of the radiant heat without exposing the gases directly to the flame of the furnace. This furnace is known as the "carborundum" furnace. Fig. 2 shows a pipe still provided with this type of furnace. The furnace is an internally fired combustion chamber made from a material consisting mainly of carborundum. Carborundum, being made in electric furnaces, will stand up under any temperature and under all ordinary conditions, and if allowed to radiate its heat will be good for continued use even over a period of years.

Carborundum has a high factor of heat conductivity, so that the heat generated within the furnace is quickly transferred through the walls from which it is being transmitted by radiation. It is claimed that fully 50 per cent of the heat generated can be made effective as radiant heat, so that the heat of the gases leaving the furnace is materially reduced. It is also claimed that the material used for this furnace is very dense and strong. The impinging action of the burner flame, therefore, has no effect upon it. The carborundum furnace can be made in almost any reasonable size. The standard sizes are capable of burning from 2 to 100 gal. of oil per hour.

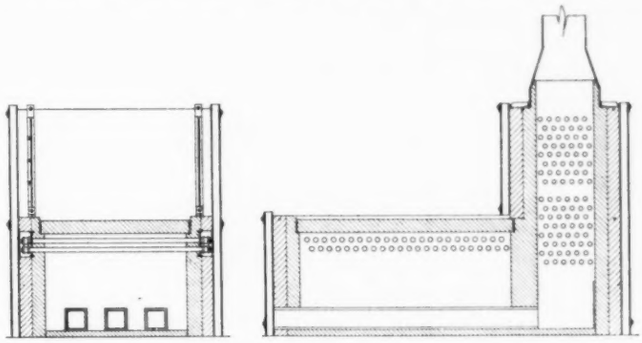

FIG. 2 PIPE STILL WITH CARBORUNDUM FURNACE

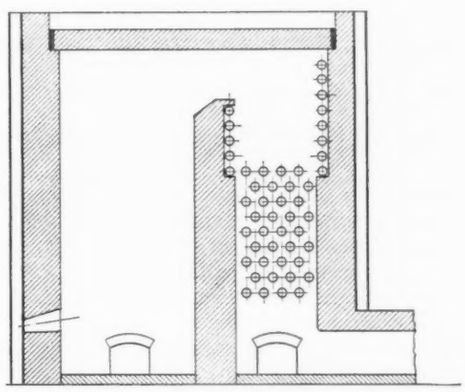

FIG. 3 PIPE STILL WITH A NUMBER OF TUBES ABSORBING HEAT ONLY BY RADIATION

They vary in cross-section from approximately 6 sq. in. to 3 sq. ft. They can be set up in lengths of from 3 to 30 ft.

The furnace is usually fired in the bottom section, combustion starting close to the burner tip and progressing through the entire length toward the back. If it is necessary to burn more fuel than the capacity of a single carborundum furnace will provide, two or more furnaces should be installed. It seems that with this furnace less excess air will be necessary than in general practice. A higher CO_2 content can be obtained with the same temperature of the gases reaching the oil tubes. Due to the fact that a portion of the heat generated by the combustion of the fuel is transmitted through the walls of the furnace and absorbed by oil tubes as radiant heat, the actual temperature of the gases leaving the carborundum furnace is materially reduced, so that the pipe still can be so arranged that gases of a desired comparatively low temperature will come in direct contact with the oil tubes. At the same time, however, a considerably better utilization of the fuel in the furnace can be accomplished. One of the main requirements of a pipe still—that the gases be evenly distributed over the entire length of the tubes—is not met by this furnace, as all the gases from the carborundum furnace are ejected from a comparatively small area. Fig. 3 shows another arrangement where radiant heat can be utilized and in which this disadvantage is eliminated.

HEAT TRANSMISSION IN PIPE STILLS AND HEAT EXCHANGERS

The whole subject of heat transmission in pipe stills and heat exchangers is as yet comparatively uncertain. Data from heat transfer in boilers cannot be applied to the case of oil stills, because in boilers part of the heat is absorbed by the process of evaporation, while in pipe stills most of it is used to increase the temperature of the oil, and the tube temperature naturally has to follow this increase. Furthermore a number of tests have been made and formulas established for heat transmission from gases to tubes. Practically all of them, however, were limited to gases flowing inside a tube. Based on theoretical analyses and experimental tests, H. Reiher comparatively recently made a study of heat transmission in Munich, Germany,[2] from gas flowing outside of tubes with different tube arrangements—in straight and staggered rows, and with different numbers of tubes. For pipe stills, only staggered arrangements of many rows of tubes need be considered.

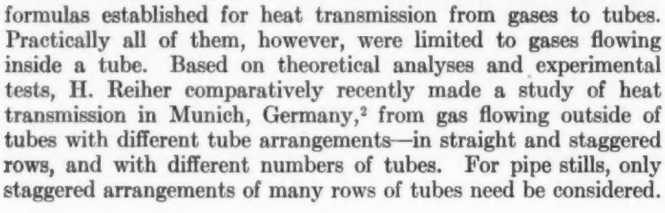

FIG. 4 LOGARITHMS OF HEAT-TRANSFER COEFFICIENT AND OIL VELOCITIES OF PIPE STILLS WITH 4-IN. AND 2³/₈-IN. TUBES

Reiher found that the relation between the heat transmission and the factors influencing it can be expressed in a formula of the following nature:[3]

$$h = C\frac{\lambda}{d}\left(\frac{wd\rho}{\mu}\right)^n$$

where the constant C and the exponent n depend upon the arrangement of the tubes. For staggered tubes in two rows:

$$C = 0.100 \qquad n = 0.69$$

for three rows:

$$C = 0.113 \qquad n = 0.69$$

for four rows:

$$C = 0.123 \qquad n = 0.69$$

for five rows:

$$C = 0.131 \qquad n = 0.69$$

H. Reitscher[4] also made a study of heat transmission between gases and tubes, the gases being outside of the tubes. He found the same relation to obtain as did Reiher, but his constants and exponents were somewhat different (See Appendix No. 1).

Reitscher conducted his tests with rather low gas velocities, while Reiher used considerably higher velocities. It seems that a compromise between the two, particularly for the lower velocities, would give the correct results (see Appendix No. 1).

The above formula gives the heat transmission between the gases and the tubes per hour per unit of surface area per degree temperature difference between the gas and the metal of the tube. It is independent of how the heat is absorbed from the tube inside, so that it can also be applied to pipe stills. The fluid inside of the tube will influence the temperature of the metal, and in this way also the total heat transmission from the gas.

From results of tests with two pipe stills having respectively 4-in. o.d. tubes ³/₈ in. thick and 2³/₈ in. o.d. tubes ¹/₄ in. thick, the author determined, applying the above formula, the temperature of the tube wall at different parts of the stills, and from this the heat-transmission coefficient between the tubes and the oil. This coefficient varies with the velocity of the oil and its viscosity, and also with the diameter of the tube. No attempt was made to determine the influence of the oil viscosity upon the heat transmission, but a number of readings at different oil velocities with approximately the same viscosity or the same temperatures led the author to certain conclusions which may be of general interest.

The oil used in the 4-in. still was heavy Mexican crude oil of 12 deg. Baumé. In the 2³/₈-in. pipe still, gas oil of 36–40 deg. Baumé was used. In the former the oil was heated from 400 to 850 deg. fahr.; in the latter, from 600 to 900 deg. fahr. At this high temperature the viscosity of the oil is comparatively low and is not reduced appreciably with the increasing temperature. The coefficient was determined for each of the above two tube sizes separately. An effort was made to develop relations between the heat transfer and the velocity of the oil in the tube. The general relation can be expressed in the following equation:

$$h = x^m$$

The exponent m was determined in the following way. If

$$h = \text{Const. } w_0^m$$

then

$$\log h = m \log w_0 + \log \text{Const.}$$

where h = coefficient of heat transfer in B.t.u. per hr. per sq. ft. per deg. fahr., and
w_0 = velocity of oil inside tube, ft. per sec.

By plotting the logarithm of h against the logarithm of the oil velocity the curve gives the expression for the exponent m. If it is a straight line, the exponent has a constant value. The section on the ordinate gives the logarithm of the constant.

In Fig. 4 the logarithms of h have been plotted as ordinates and those of w_0 as abscissas for both pipe stills. While all the points, particularly those for the smaller still, do not follow directly in a straight line, this, however, is probably due to the slight changing of the viscosity with the slightly changing temperature, and it is reasonable to assume that if all the readings could be taken at exactly the same temperature or the same viscosity, these points would be closer to the straight line.

From this we may conclude that the exponent m for the 4-in. still is 0.84, while for the 2³/₈-in. still it is 0.87. The constants are 44.5 and 48.1, respectively, for the two stills. The difference is to be expected, as in general, all other conditions being the same, the heat transmission increases with decreased tube diameter. The above constants or coefficients hold for the sizes of the pipes mentioned, for oil temperatures between 400 and 900 deg. fahr., and for velocities of from 2 to 8 ft. per sec. While, as mentioned above, the heat transmission in pipe stills depends upon the viscosity of the oil, for cracking, where the oil temperatures are very high, the viscosity will have a comparatively slight influence. When the pipe still is used for heating oil, particularly heavy oil, lower values for the heat-transmission coefficient should be taken.

The heat-transfer coefficient between the gases and the tube, and the oil and the tube, enables us to determine the temperature of the tube wall under certain conditions. The knowledge of the wall temperature is very important in connection with the operation of a pipe still. For instance, in the production of lubricating stocks or in the running of any crude, it is extremely desirable to eliminate the pyrogenic decomposition. The temperature of the oil immediately near the tube wall is higher than the average temperature of the oil. It is therefore important, when the pipe still is used for heating crude oil, to have the temperature of the tube metal not too high in order not to overheat the oil near it.

In cracking, it is very essential that the temperature of the oil shall not exceed a certain level. The object of cracking is to alter the heavy molecules so that low-boiling hydrocarbons will be

[2] Mitteilungen über Forschungsarbeiten (Berlin), V.D.I. Heft 269.
[3] For nomenclature see Appendix No. 1.
[4] Mit. der Prüfungs Anstalt für Heizungs und Lüftungseinrichtungen der Technischen Hochschule Berlin, Heft 3.

produced that would not appear on ordinary distillation. An excessive temperature will mean a large production of products of decomposition. As soon as the action begins to be a total decomposition, permanent gases will be formed, and both carbon and heavy asphaltic bodies will remain as residue.

It is therefore very desirable that the temperature of the metal of the tubes in which oil is being cracked be kept below a predetermined point. As a matter of fact, the author is of the opinion that too little consideration is at present given to the metal temperature of tubes in pipe stills. If this were done, less "fixed" or uncondensable gas and less carbon would be formed, so that the cracking of oil would be more profitable.

The foregoing heat-transfer constants and exponents apply to bare steel pipes, clean inside and outside, and when the heat is absorbed by convection only, and in no degree by radiation. If the tubes are covered inside with carbon or outside with soot, the heat-transmission coefficient is accordingly lower. The subject of heat absorption by radiation in furnaces as well as from non-luminous hot gases is discussed in a paper presented by the author at the annual meeting of the Society in December, 1925.[5]

A number of pipe stills have been installed with the so-called extended surface, or tubes covered with cast-iron sleeves or gills which increase the surface in contact with the hot gases. As the principal resistance to the heat flow from gases to oil is on the gas side, an increase of the surface exposed to the gases per unit of length seems to be beneficial. The total length of the coil required to absorb a certain amount of heat can be reduced appreciably, and correspondingly the pressure through the coil would also be reduced. When the still is used for heating oil to a comparatively low temperature, or when light oil is heated even to higher temperatures, extended surface seems to be advantageous. It should not be forgotten, however, that with the extended surface a new resistance to the heat flow is introduced, namely, that between the cast-iron gills and the steel tube, which resistance increases the longer the still is in operation. As with the extended surface a certain amount of heat can be absorbed with a shorter tube length or with less inside heating surface, the temperature difference between the oil and the tube wall must necessarily be correspondingly greater. As mentioned above, high tube-wall temperatures are undesirable with a pipe still used for cracking. From this one would conclude that for cracking stills, whenever possible, bare tubes should be used.

Also with heat exchangers between oil and oil, or between oil and water, it is advisable to consider separately each individual film resistance, or the heat transfer between each of the fluids and the wall.

Very interesting and accurate tests with heat transmission in oil coolers were made by E. Heinrich and R. Stueckle[6] at Stuttgart. Five different arrangements of coolers were tested. The oil was cooled by water. One cooler was a double tube with the inside brass tube about $1\frac{1}{4}$ in. o.d. and 0.04 in. thick, and the outside steel tube $3\frac{1}{4}$ in. i.d. The second consisted of a bundle of brass tubes of the same size enclosed in a shell, with water inside and oil outside the tubes, both flowing parallel to each other but in opposite directions.

The third, fourth, and fifth coolers were standard commercial heat exchangers with baffles inside forcing the oil to change its direction and flow more or less perpendicular or normal to the tubes. The oil used for the tests had a specific gravity of 0.86 and a viscosity of 148 Saybolt seconds at 100 deg. fahr. The tests apparently were carried out carefully. The coolers themselves as well as the weighing and measuring apparatus were all in good condition. The results, therefore, should be very reliable.

From a comparison of exponents for all five coolers in these tests it would appear that where the oil flows normal or practically normal to the tubes carrying the water, the heat-transmission coefficient varies with the 0.3 power of the velocity of the oil. This seems to be independent of other conditions and of the design of the cooler. The exponent, however, increases the nearer the flow is streamline or parallel to the tubes carrying the water. Where the flow is parallel all the way, the heat transmission increases in the same proportion as the oil velocity. To a certain extent the above is true of all heat exchangers, as will be shown later.

By the above-mentioned heat-transmission coefficient in connection with the oil heat exchanger is meant the total heat-transmission coefficient between one fluid and the other. As the heat transmission between water and a tube under different conditions is fairly well established,[7] the author has endeavored to determine, first, the water-film coefficient for the most important tests; second, the heat transmission between the metallic walls and the oil; and third, the constants and exponents of the heat transmission depending upon the oil velocities. The results are given in Table 1.

Table 1 gives the coefficient h for oil of three different coolers at different oil velocities. With all coolers h increases with the oil velocity. It also increases with the oil approaching normal or perpendicular flow to the tubes.

Table 2 gives the constants and velocity exponents for the same

TABLE 1 HEAT-TRANSFER COEFFICIENT h BETWEEN OIL AND TUBES IN OIL COOLERS

	h, B.t.u. per hr. per sq. ft. per deg fahr.	Water velocity, ft. per sec.	Oil velocity, ft. per sec.	Oil temp. deg. fahr.
Cooler I—Oil flow parallel to tube	23	0.89	1.66	179
	32	0.88	2.38	180
	43	0.89	2.93	181
	51	0.88	3.53	181
Cooler II—Oil flow parallel to tubes almost over the entire length, and normal to tubes at inlet and outlet	45	0.42	2.21	168
	39	2.30	2.21	162
	35	0.77	1.84	165
	40	0.77	2.16	166
	47	0.77	2.62	168
	52	0.76	3.28	169
Cooler IV—Normal to tubes over the entire length	53	0.33	0.46	130
	77	0.32	0.86	141
	96	0.33	1.23	141
	92	0.33	1.23	144
	116	0.33	1.53	143
	140	0.33	1.82	144
	153	0.32	1.84	147

TABLE 2 CONSTANTS AND VELOCITY EXPONENTS FOR HEAT TRANSMISSION IN OIL COOLERS

(C = constant and m = exponent of heat-transfer coefficient depending on velocity.)

	C	m
Cooler I—Oil flow parallel to tube	14	1.00
Cooler II—Oil flow parallel to tubes almost over the entire length, and normal to tube at inlet and outlet	23	0.72
Cooler IV—Oil flow normal to tubes over the entire length	84	0.63

exchangers. It is interesting to note that with cooler I the exponent is 1, which shows that the heat transfer between oil and a tube increases in direct proportion to the oil velocity when the oil flows parallel to the tubes. It increases, however, with the 0.63 power of the oil velocity when the oil flows normal or perpendicular to the tube. It is reasonable to assume, and has also been verified in many instances in practice, that this applies to practically all heat exchangers independently of what the other heating or cooling fluid is, so long as the oil velocity is high enough or the flow is turbulent.

On the other hand, the constant is smallest with the oil flow parallel to the tubes, and is greatest with the flow normal to the tubes.

Heat transmission in heat exchangers also depends upon the viscosity of the oil. Interesting experiments were conducted with oil heated by steam in the Research Laboratory of the Rensselaer Polytechnic Institute.[8] All other conditions being the same, the heat transmission between oil and the tube varied from 49 B.t.u. per hr. per sq. ft. per deg. fahr. temperature difference for kerosene with a viscosity of 36–40 Saybolt seconds at 100 deg. fahr., to 40 B.t.u. for crude oil of 53 Saybolt seconds at 100 deg. fahr. and 30 B.t.u. for cylinder oil with a viscosity of 95 Saybolt seconds at 212 deg. fahr.

Frictional Losses in Oil Flowing Through Tubes

Most of the modern pipe stills are arranged so that the oil flows through all tubes in series. In a cracking still where the temperature of the oil is to be raised 300 to 600 deg., the total length of the tubes through which the oil flows may be 2000 ft. or more, and as it is desirable to have high oil velocity in the pipe still, the friction loss or pressure drop in the still becomes very high.

[5] Radiation in Boiler Furnaces, MECHANICAL ENGINEERING, February, 1926, p. 133.

[6] Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, V.D.I., Berlin, Heft 271.

[7] McAdams, et al., in Publications of the Massachusetts Institute of Technology, Serial Nos. 17, 40, 77, 92 and 121.

[8] MECHANICAL ENGINEERING, vol. 43, no. 9, p. 616.

At the same time it is of importance that the oil be heated gradually and uniformly in a pipe still. In cracking oil it is very important that the oil be of the same temperature throughout the cross-section of the pipe. With low oil velocity, or where the flow is parallel to the tubes, the layers of the oil nearer to the tube wall are considerably hotter than those in the center. With high velocity, or in the turbulent region, however, the heated outer layers of the oil are constantly carried into the cooler core of the pipe and a more constant temperature throughout the cross-section of the pipe is obtained.

The study of the flow of oil through pipes and the frictional loss is therefore an important factor in connection with pipe stills.

It has been found from experiments that the frictional factor f must be some function

$$f = \phi\left(\frac{dw\rho}{\mu}\right)$$

of the pipe diameter d in ft., the average fluid velocity w in ft. per sec., the density ρ in lb. per cu. ft. and the viscosity z in poundal-seconds. When plotting f against $\phi\left(\frac{dw\rho}{\mu}\right)$ a single curve, Fig. 6, is obtained which is sufficiently accurate for ordinary purposes.

This curve shows that at constant velocity in a given pipe all liquids of the same kinematic viscosity have equal loss of frictional head. Liquids of the same kinematic viscosity have equal Saybolt seconds. From this it follows that for flow at the same velocity in the same pipe, liquids of the same Saybolt viscosity have equal loss of frictional head. This fact is of great importance as it allows a determination of the kinematic viscosity from the viscosimeter readings and Fig. 5, by means of which, for any given flow velocity and pipe diameter, the frictional factor f may be computed.

As might have been expected, the curve of Fig. 6 consists of two branches, one for straight-line flow, and the other for turbulent flow. The branch for the straight-line flow is a straight line with a slope of 45 deg., and its intercept on the axis of ordinates is 64. The equation for this line is $f = 64 \div (dw/\mu)$. The other branch is curved and no practical mathematical expression is available. The value of the critical region is clearly seen, and it will be found that straight-line flow changes to uncertain flow at $dw\rho/\mu = 2000$, and then changes again to regular turbulent flow at $dw\rho/\mu = 3000$.

If μ = viscosity of main body of fluid, poundal-sec.
ρ = density of main body of fluid, lb. per cu. ft.
d = actual inside diam. of pipe, ft.
L = length of straight pipe, ft.
w = average velocity of fluid, ft. per sec.
h = pressure drop due to friction, ft., and
g = acceleration due to gravity = 32.2 ft. per sec. per sec. then

$$h = \phi\left(\frac{dw\rho}{\mu}\right) \times \frac{L}{d} \times \frac{w^2}{2g} \quad \ldots\ldots [1]$$

corresponding to the Fanning equation:

$$h = f \times \frac{L}{d} \times \frac{w^2}{2g} \quad \ldots\ldots [2]$$

which gives

$$f = \phi\left(\frac{dw\rho}{\mu}\right)$$

Critical region:

$$2000 < \frac{dw\rho}{\mu} < 3000 \quad \ldots\ldots [3]$$

If the frictional loss is to be expressed in pounds per square inch, multiply the above value of h by 0.433 and by the specific gravity of the fluid.

Allowance must be made for loss at bends and valves. Most engineering handbooks give the loss in terms of an equal length of straight piping. The equivalent lengths should be added to the straight length of the piping before finally deciding on the total loss, to make sure that this is not greater than permissible.

The method of computing the pressure drop or loss of head due to friction will then be:

1 To obtain the viscosity and density of the liquid at the required temperature.

2 If the obtained value is in Saybolt seconds, to convert these into kinematic viscosity μ/ρ by means of Fig. 5.

3 Insert μ/ρ together with the assumed values of d and u in [3]. If the value is within the critical region, d or u must be changed.

4 Enter the value of $dw\rho/\mu$ in Fig. 6 to obtain the frictional factor.

5 Insert the value of f in [2] which will give the desired frictional loss.

For rough or corroded pipe or where the fluid may decompose

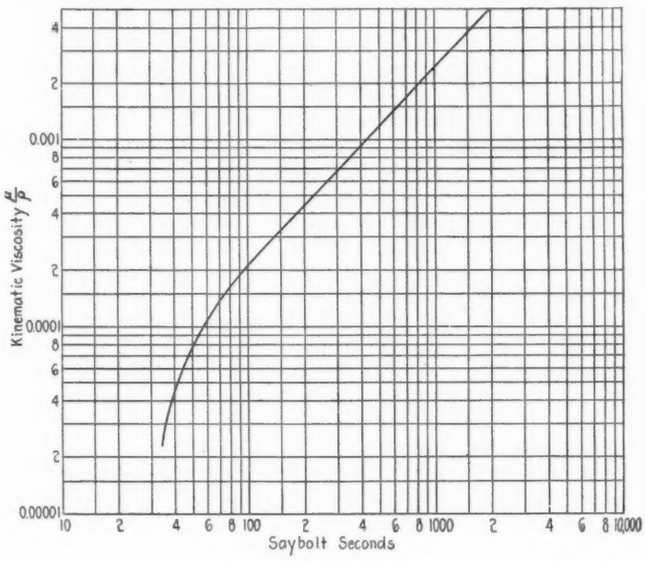

FIG. 5 CONVERSION CURVE BETWEEN SAYBOLT SECONDS AND KINEMATIC VISCOSITY μ/ρ

Values of $\frac{dw\rho}{\mu}$ (For Upper Curve)
10 2 4 6 8 100 2 4 6 8 1000
Friction Factor f
1.0
0.1
0.01
1000 2 4 6 8 10,000 2 4 6 8 100,000 2 4 6 8
Values of $\frac{dw\rho}{\mu}$ (For Lower Curve)

FIG. 6 CURVE SHOWING RELATION BETWEEN THE FRICTIONAL FACTOR f AND $dw\rho/\mu$

or deposit solid matter on the wall, an amount by which f must be increased should be determined. This can only be a matter of judgment in each particular case, as no definite method exists.

The formulas do not apply to heavy tar-like oils of very high viscosity, as these oils in some ways behave more like solid matter. It has been shown that the critical velocity is proportional to the kinematic viscosity. If it were attempted to exceed the critical velocity for such heavy oils, this would result in very high pressures and correspondingly excessive frictional losses.

The formulas are based upon experiments with drawn steel or brass pipe. When the method is applied to wrought-iron pipe 1 to 6 in. in diameter, add to the frictional losses 12 to 3 per cent.

The viscosity of oil is greatly influenced by the temperature, as mentioned above.

Table 3 gives the pressure drop in pounds per square inch for

TABLE 3 PRESSURE DROP OF OIL FLOWING IN PIPE—FRICTION HEAD IN FT. PER 100 FT. OF PIPE

Pipe diameter, in.	Oil velocity, ft. per sec.	Viscosity in Saybolt Seconds 50	100	150	200	300	400	500	600	800
1	2	2.60	6.38	10.00	13.60	20.70	27.70	34.60	41.50	55.50
	4	12.40	12.76	20.20	27.20	41.40	55.40	69.20	83.00	111.00
	6	25.00	26.00	30.30	40.80	62.10	83.10	103.80	124.50	166.50
	8	41.35	53.90	40.40	54.40	82.80	110.80	138.40	166.00	222.00
	10	61.40	79.10	75.16	68.00	103.50	138.50	173.00	207.50	277.50
2	2	1.53	1.60	2.50	3.38	5.14	6.88	8.60	10.34	13.78
	4	5.12	6.65	5.00	6.76	10.28	13.76	17.20	20.68	27.56
	6	10.40	13.42	15.12	11.81	15.42	20.64	25.80	31.02	41.34
	8	17.14	22.12	24.90	26.95	20.56	27.52	34.40	41.36	55.12
	10	25.20	32.85	37.10	40.00	36.73	34.40	43.00	51.70	68.90
3	2	0.74	0.64	1.00	1.32	2.04	2.72	3.40	4.08	5.44
	4	2.48	3.21	3.31	2.64	4.08	5.44	6.80	8.16	10.88
	6	5.48	7.09	7.95	8.60	6.35	8.50	10.62	12.75	17.00
	8	9.78	12.70	14.35	15.51	17.00	12.80	14.87	17.85	23.80
	10	15.15	19.85	22.10	24.05	26.90	27.30	21.50	22.95	30.60
4	2	0.64	0.83	0.64	0.84	1.28	1.72	2.16	2.60	3.44
	4	1.91	2.47	2.78	2.88	2.40	3.23	4.03	4.85	6.44
	6	3.84	5.00	5.67	6.10	6.46	4.85	6.04	7.28	9.65
	8	6.32	8.30	9.26	10.10	11.23	11.72	9.03	9.71	12.86
	10	9.35	12.15	13.70	14.78	16.57	17.85	17.70	14.70	16.07
6	2	0.37	0.48	0.53	0.41	0.56	0.75	0.94	1.12	1.48
	4	1.23	1.60	1.80	1.94	2.14	1.55	1.89	2.24	2.97
	6	2.72	3.54	3.98	4.30	4.80	5.16	5.05	4.28	4.69
	8	3.98	4.97	5.56	6.36	6.96	7.55	7.95	8.54	6.36
	10	5.90	7.14	8.07	9.00	9.93	10.85	11.79	12.40	12.40
8	2	0.24	0.31	0.36	0.39	0.30	0.39	0.56	0.60	0.86
	4	0.82	1.05	1.20	1.31	1.46	1.57	1.24	1.20	1.61
	6	1.68	2.10	2.35	2.60	2.94	3.11	3.36	3.52	2.78
	8	2.83	3.58	3.88	4.33	4.77	5.21	5.66	5.81	4.62
	10	3.97	5.36	5.83	6.30	7.00	7.46	8.16	8.39	9.32

different pipe diameters, different oil velocities, and different oil viscosities.

MECHANICAL DESIGN OF PIPE STILLS AND HEAT EXCHANGERS

As mentioned above, the main reason for the rapid development of the pipe still is due to the fact that oil flows through the tubes with high velocity, protecting them from overheating. Particularly in cracking stills, the high velocity of the oil keeps the liberated carbon in suspension and carries it along so that it settles in containers which are not in contact with the hot gases, and from which it can be removed easily. With earlier pipe stills, various devices had to be used in order to protect the bottom of the shell directly exposed to the furnace. None of these devices, however, were as effective as the high velocity of the oil. Tubular heaters on pipe stills are therefore now being used successfully whenever it is necessary to heat oil, particularly for higher pressures. They are used for reheating oil before fractionating, for rerunning light distillates, but more particularly, however, for cracking oil by various processes.

There is liable to be one difficulty with pipe stills. In the old shells any carbon accumulating at the bottom could be removed comparatively easily by having the shell cooled off so that a man could get inside through a manhole or other opening placed in a convenient location and remove the carbon. The only way to clean pipe stills is from the tube ends. The pipe still must therefore be so constructed that each end of the tubes is easily accessible.

One of the first pipe stills built was in connection with the Burton process. It was designed similar to a water-tube boiler where the tubes are rolled in headers having handholes opposite the tube ends. These stills have only natural circulation and the velocity of the oil is therefore comparatively small. However, the advantage of high velocity in pipe stills is now fully recognized, and those in connection with other processes are arranged so that the oil flows through the tubes which are in series and have return bends on the ends. Stills must be so designed as to allow access to the tubes.

The recently developed pipe stills are made of straight lengths of pipes connected by return headers to form a continuous coil or series of coils. There is a handhole opposite the end of each tube, closed by a removable tapered, screwed, or ball plug. In some designs the entire return head is made removable. All of the return headers and plugs are exposed by opening a door in the setting wall, and the tubes are then opened for their entire length by removing the return head or the plug opposite each end. A cleaner or scraper can be put through every tube without cooling down the setting and with a minimum of effort.

The application of the pipe still has considerable influence upon the design of the return bend and joint. For instance, if heavy oil is heated to high temperatures and pressures, a part of it becomes decomposed or cracked to a lighter oil, in which case carbon necessarily deposits in the tube and has to be removed frequently. For this reason the accessibility of the ends is of utmost importance. When naphtha is heated to a moderate temperature at low pressure, less expensive joints can be applied.

The frequently used cast-steel return heads, into which two tube ends are expanded and which are provided opposite the tube holes with screwed or handhole tapered plugs, are well known and need not be described here.

Fig. 7 shows the tube assembly of a pipe still applicable for cracking of oil at high temperatures and pressures. Of particular interest is the joint, Fig. 8, between the return bend and the pipe. This ball clamp joint consists of a pipe *A*, the ends of which are offset to a ball end in a forging machine and then machined and ground to correct contour. The return bend *H* is of cast steel and the

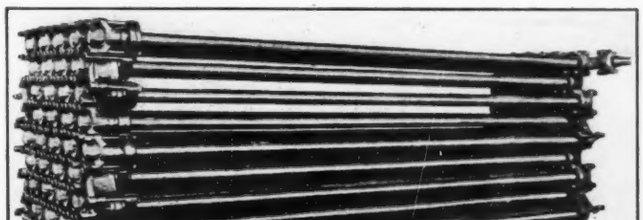

FIG. 7 ASSEMBLY OF TUBES AND RETURN BENDS FOR A PIPE STILL

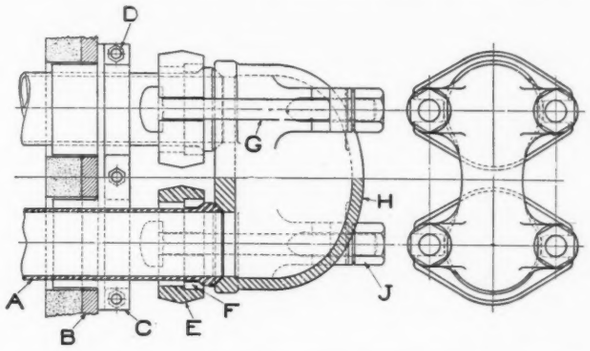

FIG. 8 DETACHABLE JOINT BETWEEN A TUBE AND A RETURN BEND

seat to receive the pipe ball ends is machined and ground to 45 deg. The clamp *E* for securing the tubes to the return bend is of drop-forged steel in which is inserted a split washer *F*, the removal of which permits the application and removal of clamp *E* over pipe ends. The connecting bolts and nuts are made from high-grade alloy steel. This arrangement has proved very satisfactory for the severe service of a pipe still for oil at high pressures and temperatures. Many refineries now consider it the most reliable and safest joint for this service. This arrangement has also the advantage that a tube can be transferred from one location to another in the pipe still and can also be turned in its place.

In cases where a comparatively inexpensive construction is desired and where replacement of tubes cannot be accomplished in a short time, the design shown in Fig. 9 offers some advantage. Since commercial pipes can be used, it is not necessary to have them go through a shop. These designs consist of a return bend into which the tubes are expanded and which are provided with ball plugs opposite the two ends. These designs are recommended where either heavy or light oil is heated to moderate temperatures. For large pipe stills, sometimes a combination of any two of the above designs can be applied, in which case joints like that of Fig. 9 are placed in the cooler part of the still.

Fig. 10 shows return bends made from either drop forgings or cast

steel. In this design the closure cup, which is inserted in a tapered seat, is held securely by means of a holding member and setscrew, which are in turn held by overhanging lugs or a yoke. The application of a graphite paste is required on the cup in order to insure tight joints for high pressures and temperatures.

The arrangement of the tubes with respect to the gas flow is worthy of serious consideration. From many pipe stills the author has observed in operation he has found that whenever possible it is advisable to have the gas flow downward over the tubes. Any solid carbon precipitated is heavier than the oil, and settles at the bottom of the tubes. With the gases flowing downward, the upper part of the tubes is in better contact with the gases, while the lower part hardly comes in contact with them. The carbon, therefore, does not bake on the tubes and is considerably easier to remove.

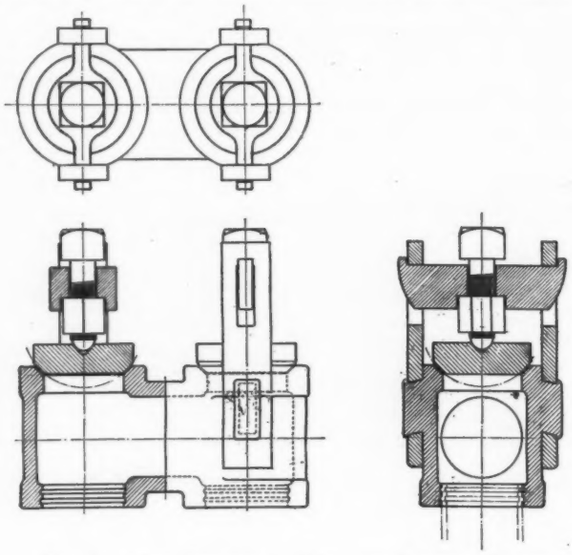

FIG. 9 JOINT BETWEEN A TUBE AND RETURN HEADER

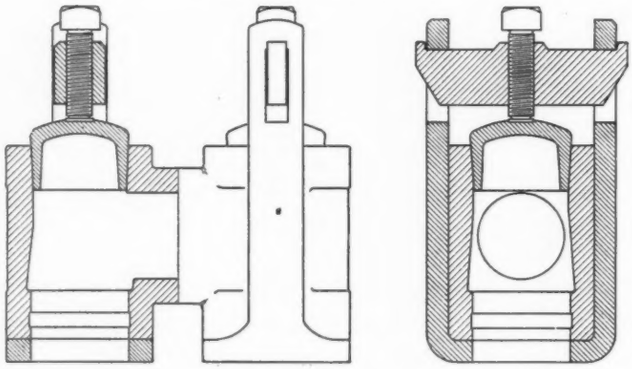

FIG. 10 JOINT BETWEEN A TUBE AND A RETURN HEADER WITH A TAPERED CUP PLUG

As in many other heat-transmission apparatus, it is advisable to have the gases flow opposite to the direction of the oil, or have the oil enter where the gases leave the still and the oil outlet where the hottest gases enter the still. With this arrangement, heat transmission is very efficient. The gases can also be cooled off to a minimum, increasing the efficiency of the still. In some cases, however, in connection with pipe stills, deviations may be advantageous.

With highly viscous oil, which would cause a high pressure drop through the still, it may be advisable to arrange the oil to enter the still where the gases first come in contact with the tubes, in order to decrease the viscosity quickly. After the viscosity is reduced a reasonable amount, the oil is carried to the lower part of the still and flows in the direction opposite to the gases.

In some cases where heavy oil is used, particularly with the gas flowing upward, a mixed-flow arrangement is found. The oil enters where the gases leave the still. It flows in the direction opposite to the gases for about half-way. It is then carried to the hottest part of the still with a comparatively low temperature and flows in the same direction as the gases, so that the oil leaves the still at a comparatively cool gas zone.

Heat exchangers are usually understood to be devices for transmitting heat from a hot fluid which is to be cooled to another liquid which is to be heated. Particular attention has been given to the design of heat exchangers in the past few years due to their wide use in the petroleum industry, especially since the development of the oil-cracking processes. These heat exchangers are of two general designs: first, the shell type as shown in Figs. 11, 12, and 13, having a bundle of tubes located in a casing or shell. A number of small smooth or corrugated tubes, straight and parallel, are either rolled, threaded, or brazed into two tube sheets, forming a tube bundle. In some cases one of the tube sheets is made integral with the round casing or shell, but in most instances it is independent of the casing. In order to take care of the difference in expansion between the tubes and the shell, the floating-head design is often applied, which can move to a slight degree independently of the shell. In some designs the floating head travels in a packing gland, which permits all joints on the heater to be external so that the smallest leakage can be detected instantly. In other heaters the floating head is merely guided in the shell, which has a separate head at that end.

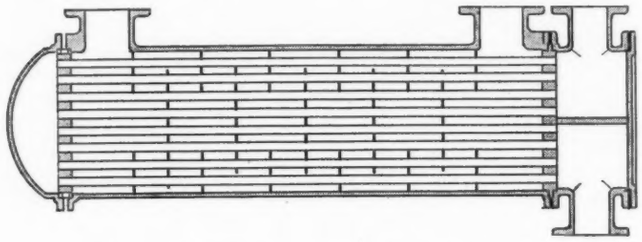

FIG. 11 HEAT EXCHANGER WITH A ZIG-ZAG BAFFLE

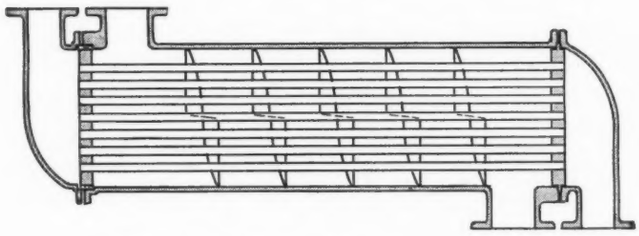

FIG. 12 HEAT EXCHANGER WITH A SPIRAL BAFFLE

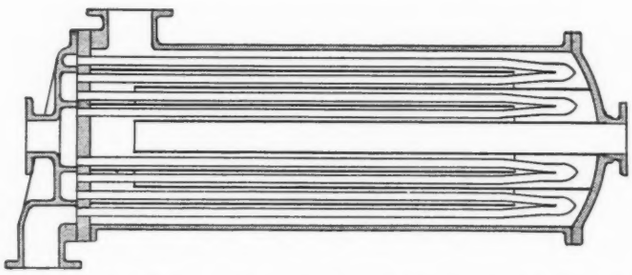

FIG. 13 HEAT EXCHANGER WITH U-TUBES CONNECTED BY FORGED RETURN BENDS

In order to increase heat transmission, the heat exchangers are very often designed with one or more passes as regards the flow through the tubes. The shell is also frequently provided with different arrangements of baffles to bring the liquid outside the tubes in better contact with the surface. In general, heat exchangers are made at least two-pass or multiples thereof in order to have the inlet and outlet to the tubes at the same end, thus making the piping and connections much simpler.

Fig. 11 shows one baffle arrangement of an exchanger by means of which the liquid is given a zig-zag flow normal to the tubes. This gives, as mentioned in a previous paragraph, a considerably better heat transmission.

Fig. 12 shows a spiral baffle arrangement. This has practically the same effect as the zig-zag, but it also causes, to a certain extent

at least, turbulent flow, which is supposed to increase still further the heat-transfer coefficient.

A rather novel arrangement of a heat exchanger is that shown in Fig. 13. The heating surface consists of U-tubes connected by return bends made by a special process of forging the pipe itself. With this arrangement each U-tube can expand individually, or independently of the others. Each leg of the U-tube can be cleaned to the very end of the return bend. The number of joints between the tubes and tube sheets for the same length of tubes is reduced one-half. Both liquids flow parallel to each other, but the arrangement of the concentric baffles causes high velocities of both

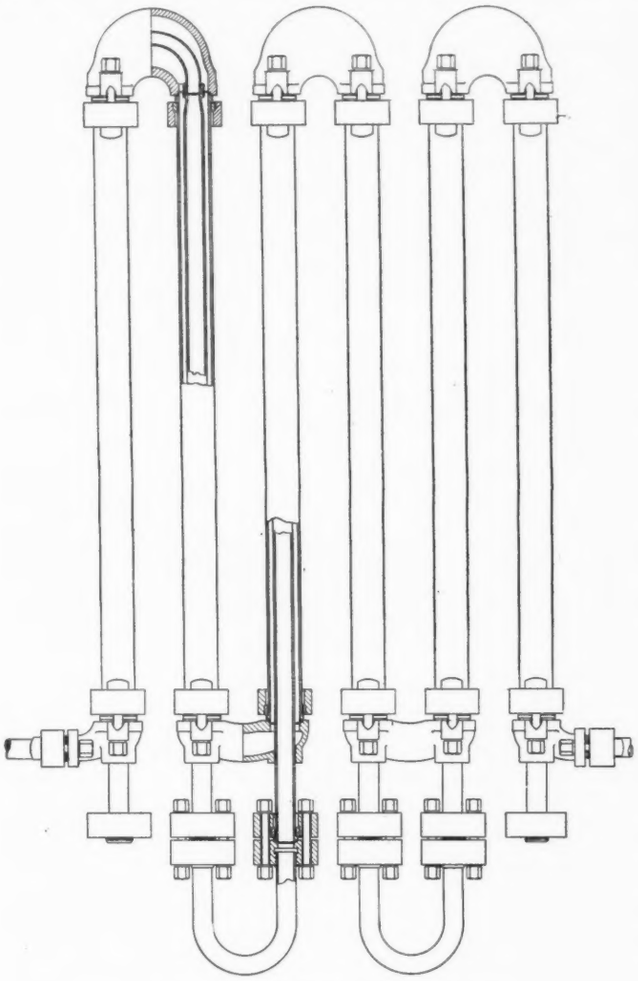

FIG. 14 DOUBLE-TUBE HEAT EXCHANGER

liquids, so that a high degree of heat transfer is secured. With this arrangement each liquid also flows counter to the other through the entire length of their travel.

The tube material to be used in oil exchangers depends upon the characteristics of the oil handled. With some oils steel tubes and sheets can be used, while with others various copper alloys must be employed to avoid chemical action of the oil on the tubes. In some cases, even the baffles must be made of non-ferrous metal. When exchangers are used as coolers and the cooling medium is salty water, it is often necessary to line the header with zinc in order to retard the electrolytic action at the tube joints.

Where the temperature difference between the liquids is high and a considerable amount of heat is to be transmitted between comparatively small amounts of oil, the double-tube type of heat exchanger is used. One arrangement of an exchanger of this type is shown in Fig. 14. It consists of sections, each having a smaller-diameter pipe concentric inside a larger one. Both pipes have their ends connected by return bends in such a manner as to form two independent flows, one inside of the other. The design of this exchanger is of interest because no gaskets are used. All connections are metal-to-metal ball joints. This design is very flexible. It is especially adaptable for high temperatures and pressures, as a large amount of expansion and contraction can easily be taken care of without objectionable strain on the joints or tubes.

Only one end of the inner tube is fixed in the return bend, common to both pipes. The other end of the inner tube is joined to a return bend which floats in the larger one of the other pipe, so that each pipe can expand or contract individually. This heat exchanger is simple to clean, as it is only necessary to remove the outside return bends and the inner tube can be withdrawn. A perfect counter-flow is possible so the heat-transmission effect is very high.

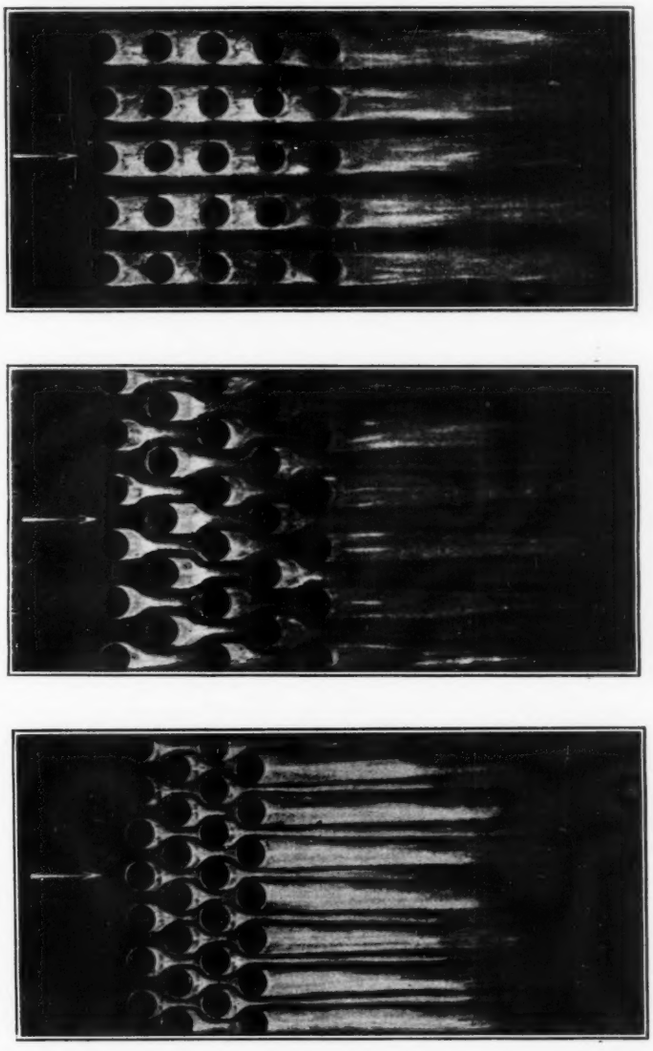

FIG. 15 GAS DISTRIBUTION OVER STRAIGHT AND STAGGERED ROWS OF TUBES

CONCLUSION

It should be seen from the foregoing why the design of oil-cracking stills lies so largely within the province of the mechanical engineer. For the most part the problems calling for solution are dependent upon matters with which he is already familiar, such as the efficient generation of heat, heat transmission, the flow of fluids, and mechanical construction for high pressures and temperatures. In furnace design it is imperative to generate heat efficiently and distribute it evenly over the heating surface, and at the same time avoid overheating of the tube bank generally or in any one part. Heat transmission in pipe stills and heat exchangers brings in the transfer of heat from gases to liquids of widely varying viscosities, also from one liquid to another of a widely differing temperature. The mechanical details call for a design that will not only withstand the action of high pressures and temperatures, but one that can be readily dismantled for cleaning and renewal of the heating units.

It is hoped by the author that he has succeeded in presenting a clearer picture to the refinery man, as well as to the mechanical

engineer, of the possibilities held by the problems in this field, and one that will induce them to exert their efforts to further advancement and improvement.

APPENDIX NO. 1

IN ORDER to determine the heat transmission from hot gases to a steel tube and to banks of tubes located normal to the flow of the gases and containing a flowing liquid, H. Reiher made extensive tests in the Research Laboratory at Munich, Germany. His apparatus consisted of tubes from 0.46 to 2.8 cm. o. d., and tests were made with air velocities of from 5 to 15 meters per second, and gas temperatures up to 200 deg. cent. By means of the law of similarity he extended his investigations to cover also heat transmission between flue gases of considerably higher temperatures and tubes of larger diameters. Coefficients were also established for banks of tubes in straight as well as in staggered rows.

Of considerable interest is Fig. 15, showing the distribution of a gas flow over banks of tubes with different tube arrangements.

H. Reitscher also made similar tests at the Research Laboratory in the Technical College of Berlin. Both experimenters found that the heat-transmission coefficient h from gas to a pipe is

$$h = C \frac{\lambda}{d} \left(\frac{wd\rho}{\mu} \right)^n$$

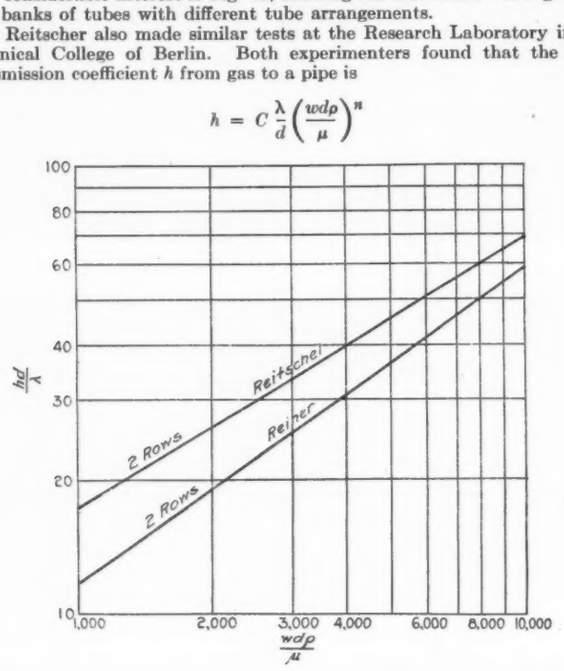

FIG. 16 CURVE SHOWING THE RELATION BETWEEN $\frac{hd}{\lambda}$ AND $\frac{wd\rho}{\mu}$

where

h = heat-transmission coefficient in kg-cal. per sq. meter per hr. per deg. cent.
λ = conductivity coefficient in kg-cal. per meter per hr. per deg. cent.
ρ = mass density in kg-sec.^{2} per meter^4
μ = viscosity in kg-sec. per sq. meter
d = pipe diameter in meters
w = maximum gas velocity in meters per second.

The exponent n is constant, while C is a function of the number of pipe rows. For the same conditions, however, the values of n and C varied slightly in the tests of the above experimenters. This seems to be due to the fact that Reitschel's formula is applied to low velocities, while Reiher's experiments do not go below 5 meters per second.

In accordance with the above

$$\log \frac{hd}{\lambda} = \log C + n \log \left(\frac{wd\rho}{\mu} \right)$$

This equation for both Reiher and Reitschel's experiments is plotted in Fig. 16. The slope of the lines gives for Reitschel,

$$n = 0.59$$

and for Reiher,

$$n = 0.69$$

The corresponding values for C are given in Table 4.

TABLE 4 VALUES OF C IN REIHER AND REITSCHEL'S FORMULAS

	Number of Tube Rows			
	2	3	4	5
Reiher	0.100	0.113	0.123	0.131
Reitschel	0.322	0.345	0.370	....

These experiments show that the heat-transmission coefficient is larger for pipes in staggered rows than in straight rows. The difference is smaller for low velocities, but increases with the velocity and with an increasing number of rows.

The experiments were not made for more than five rows. On account of the influence of the first effective tubes, the value of h and C is increasing with the number of rows. It is assumed that h is increasing up to a certain value where the influence of the first row will be negligible. In other words, C will be constant for a greater number of rows.

The lower curve in Fig. 17 shows the relation between C and the number of rows for gas velocities between 5 and 15 meters per second. As mentioned before, Reiher's experiments were not carried below 5 meters per second. For low velocities, Reitschel's formula is therefore more reliable. In order to apply Reiher's formula to low velocities, the values of the lowest point of the Reitschel curve, Fig. 16, are inserted in Reiher's formula, which gives the value of C corresponding to low velocities. For instance, the lowest point of the Reitschel curve in Fig. 16 is $hd/\lambda = 18$ and $wd\rho/\mu = 1000$ which, inserted in Reiher's formula, gives

$$C = \frac{18}{(1000)^{0.69}} = 0.153$$

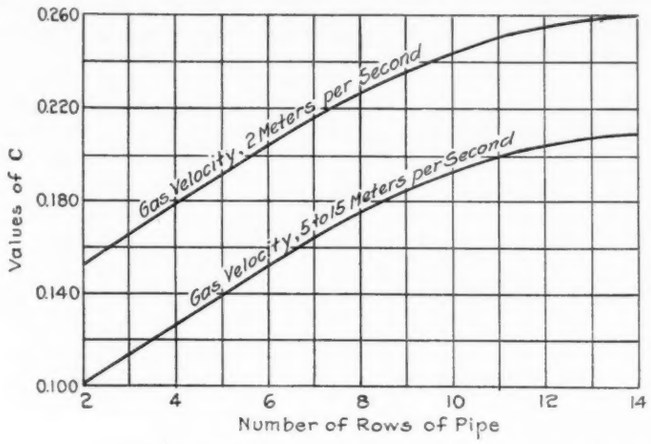

FIG. 17 CURVE SHOWING THE RELATION BETWEEN C AND NUMBER OF ROWS OF PIPE

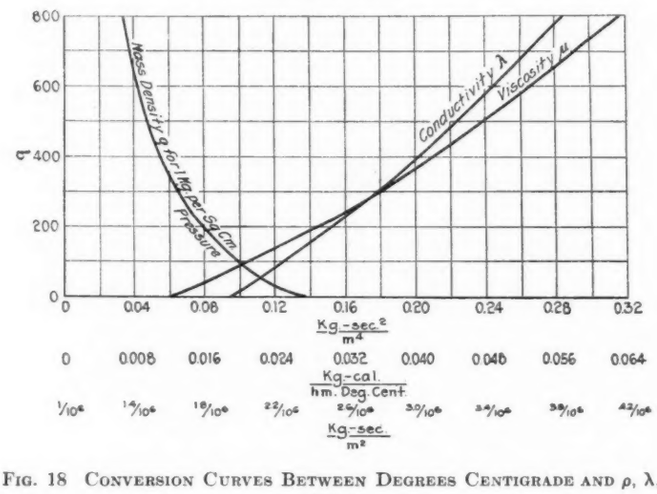

FIG. 18 CONVERSION CURVES BETWEEN DEGREES CENTIGRADE AND ρ, λ, AND μ

If we therefore draw a curve in Fig. 17 through the point (1000, 0.153) parallel to the lower curve, this should give the values of C for low velocities. Reiher's formula can be used then for high as well as low velocities, C to be taken from Fig. 17.

This method does not apply, however, for velocities lower than one meter per second, as at this velocity there is a considerable effect from natural convection. Fig. 18 gives the relation between the gas temperature in degrees centigrade and the mass density ρ, the conductivity λ, and the viscosity μ, in order to facilitate the use of the formula in figuring the heat transmission between gases and tubes.

It should be noted that the temperature in question is that of the gas film nearest the tube, and is assumed to be the mean value of the gas and pipe temperature.

Combined Oil- and Gas-Burning Furnaces for Power-Plant Use

By J. G. ROLLOW,[1] LOS ANGELES, CAL.

Because of the fact that economics does not permit the storage of gas on a scale required for dependable power-plant operation, it becomes necessary where this fuel is used to provide supplemental equipment for burning a fuel that can be stored. The logical fuel for this purpose is oil, since it is usually found in the same localities as natural gas and requires the same amount of operating labor to handle. This paper deals with combinations of equipment for best meeting the above requirement, and does not attempt to discuss the merits of either oil burners or gas burners as such.

COMBINED oil- and gas-burning furnaces may be divided into three general groups according to requirements: viz.,

I Those where gas is the major fuel and oil is used only in case of a breakdown in pipe line or compressors

II Those where gas is available for a good part of the time—say, the summer months, and where oil may have to be used for several weeks or months, besides acting as emergency for the gas

III Those where oil is the major fuel and occasionally there is some gas available, or a fairly continuous supply of gas—too small to meet the total requirements.

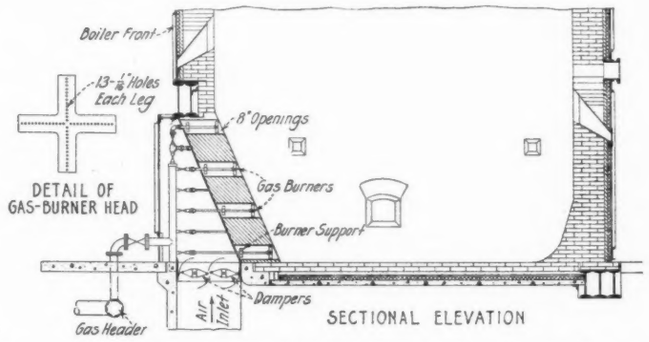

FIG. 1 TYPE OF PLANT WHERE OIL IS USED ONLY IN CASE OF FAILURE OF GAS SUPPLY

Gas-burning plants as a rule start in group I, and eventually come into group III.

Gas is the easiest of all fuels to burn. This is shown by the fact that theoretically the highest boiler efficiencies are available from coal, the next highest from oil, and the lowest from gas. Until recently the actual efficiencies obtained were in the reverse order.

Plants starting out in group I where the gas fields are nearby and the gas supply is reliable are not much concerned with the efficiency of the supplementary oil burners. Neither are they concerned with the ease and speed with which the supplementary burners can be put into operation, until they have had one or two serious interruptions. Fig. 1 is a good illustration of a plant in the early stages of group I. This plant is located in the oil fields of the Middle West, close to an abundant gas supply. It uses a very simple form of gas burner with good results. When burning oil the gas burners in the top row are removed and oil burners inserted in their places. The air for combustion is supplied in the same way as when burning gas. This change requires too much time where the gas supply is liable to fail without warning. Also the method of supplying combustion air for oil does not give economical results.

Fig. 2 shows another combination which fulfills the requirements of group I. This arrangement was used in Los Angeles when natural gas was first brought in—in 1914. It will do very well until

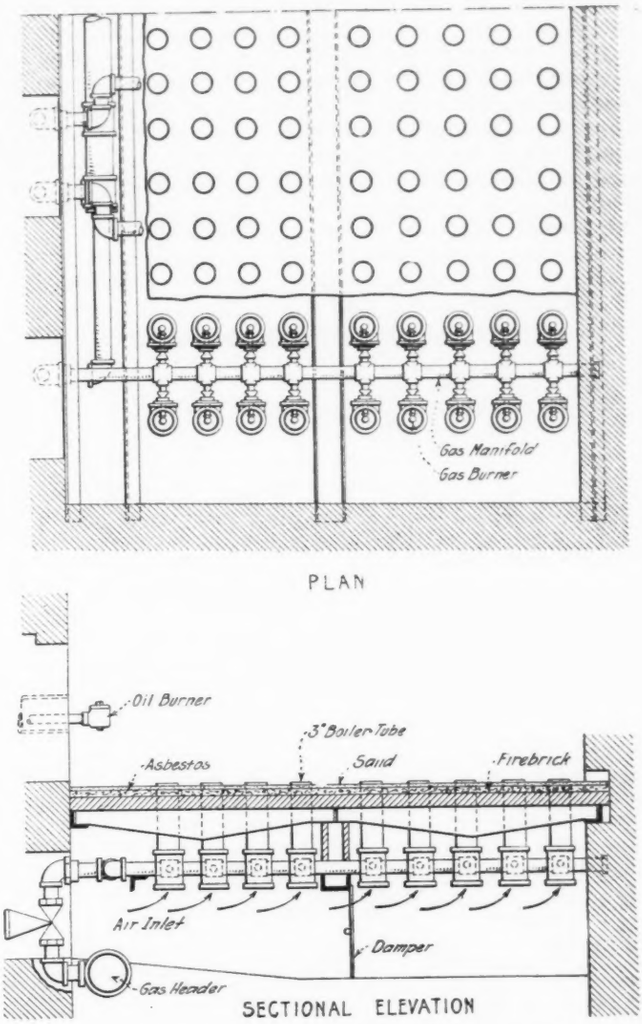

FIG. 2 ANOTHER ARRANGEMENT FOR USE WHERE GAS IS THE MAJOR FUEL

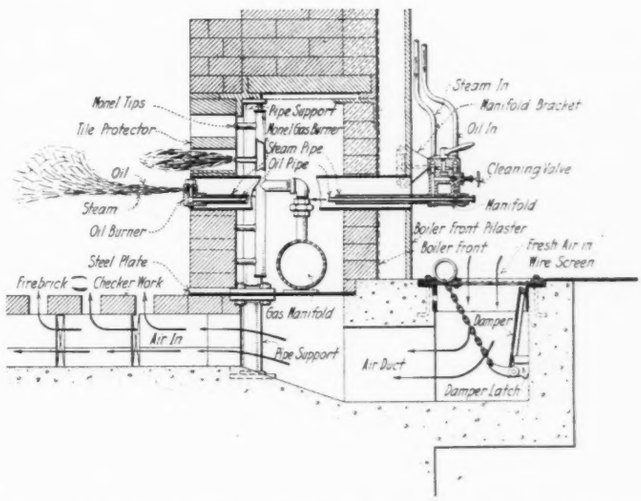

FIG. 3 ARRANGEMENT WHERE OIL IS USED SEVERAL WEEKS OR MONTHS IN THE YEAR

[1] Electrical Engineer, Los Angeles Gas and Electric Corporation. Mem. A.S.M.E.

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it becomes necessary to burn oil for a considerable period of time, in which case the rear gas-burner openings will become slagged over, rendering them inoperative. The efficiency is very good with either fuel, but the maintenance is high where oil is used for any considerable period.

When the demand for gas for domestic purposes in Los Angeles changed the requirement to group II, the combination shown in Fig. 3 was developed. This arrangement, like the two previously referred to, uses a steam atomizing burner. It can be changed from one fuel to the other very readily without the loss of load. The maintenance on it is low for ratings not exceeding 150 per cent with oil and 200 to 250 per cent with gas.

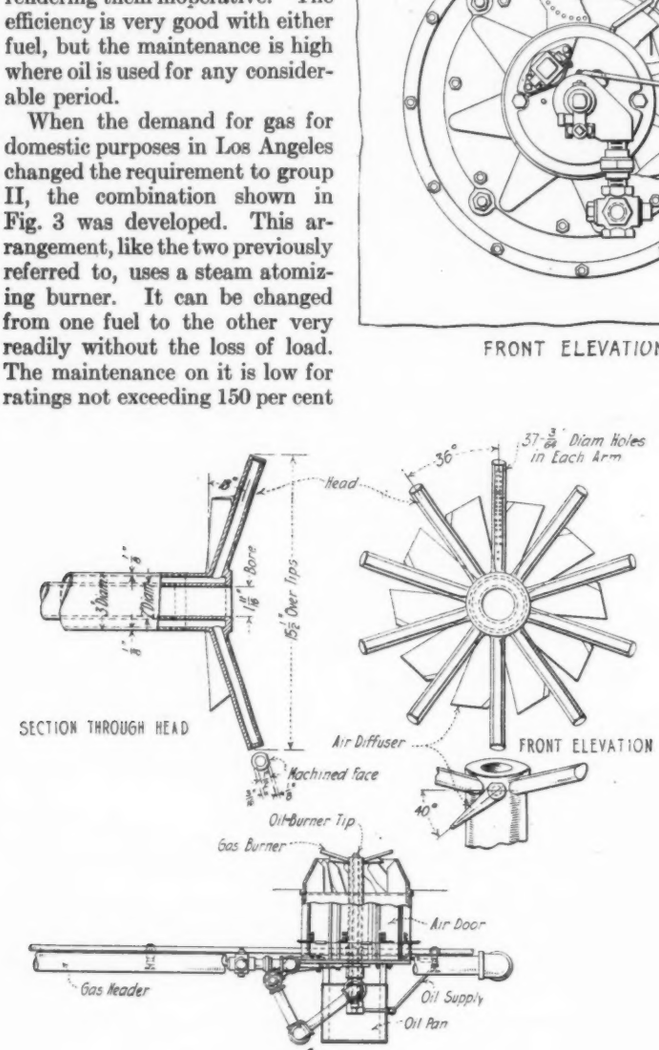

FIG. 4 COMBINED OIL AND GAS BURNER

Previous to 1922 no combinations of gas burners with mechanical atomizing oil burners had been used. During that year an installation of Babcock & Wilcox Company mechanical atomizing oil burners was made in Los Angeles, and during the following year gas burners similar to those shown in Fig. 3 were installed with them. This combination was not entirely successful because the severe furnace conditions imposed by the mechanical burners caused excessive maintenance on the gas burners.

After several experiments the combination shown in Fig. 4 was produced. This arrangement not only added an excellent gas burner, but introduced an improvement in the oil burner. The diffusers welded to the gas-burner legs stopped the furnaces from pulsating. This pulsation was formerly very severe with CO_2 above 12 per cent. The change from one fuel to the other can be made very quickly and without loss of load. The cost of the gas-burner heads with the diffusers, double swinging joints, and valve ready to connect to the gas header is $120 each. The material used in this particular case was "Fahrite." This metal resists the temperatures but is somewhat hard to machine, particularly in drilling the 3/64-in. holes. An interesting feature of the design is the double-jointed gas connection. These joints cause the burner to rotate when it is being withdrawn so that its legs maintain their relative positions with the spiral blades of the oil-burner cone. One of these burners will develop 450 b.hp. with a gas pressure of 10 lb. at the burner.

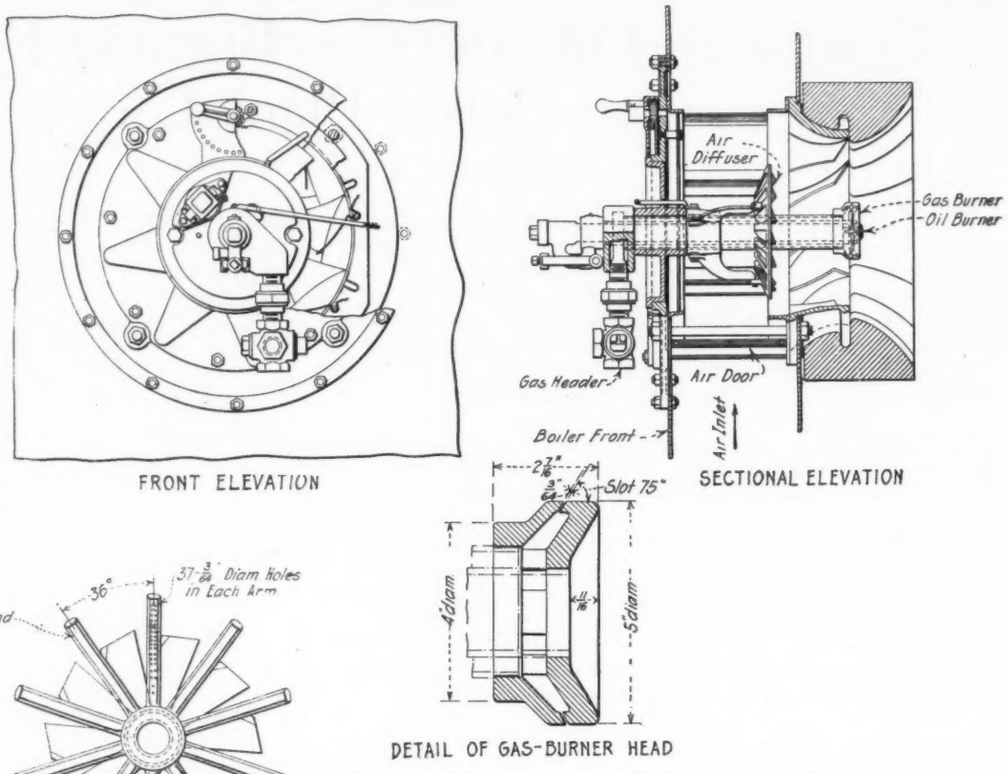

FIG. 5 COMBINATION OF GAS BURNER AND MECHANICAL ATOMIZING OIL BURNER

Another interesting combination of a gas burner with a Babcock & Wilcox Company mechanical atomizing oil burner is shown in

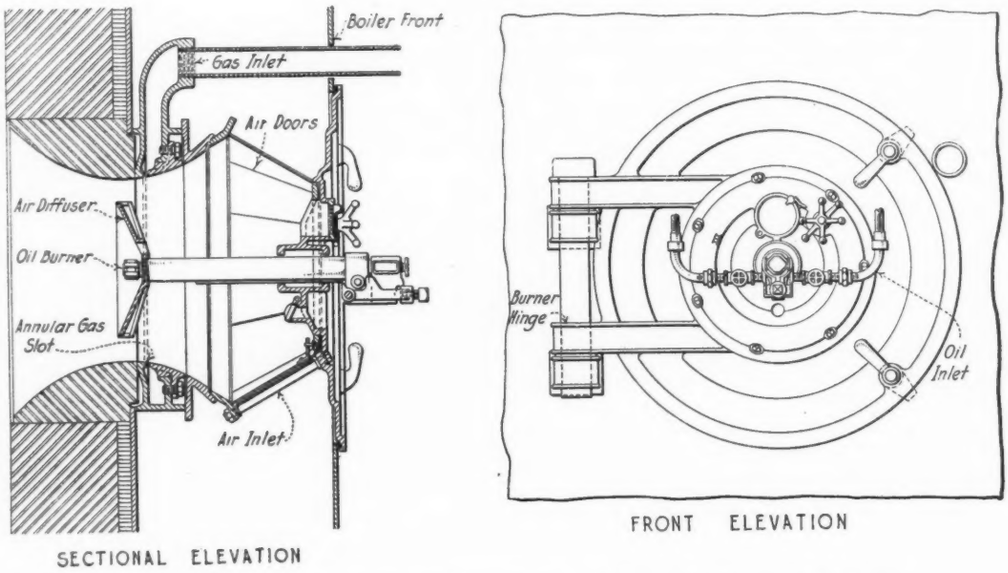

FIG. 6 ANOTHER COMBINATION OF GAS BURNER AND MECHANICAL ATOMIZING OIL BURNER

Fig. 5. In this case the gas-burner head is simpler to make than that shown in Fig. 4. It requires one more operating move, however, to change fuels, as the impeller or diffuser plate is in the position shown in Fig. 5 when gas is burned and must be moved in over the gas-burner head when burning oil. This combination is being used at Long Beach and develops approximately 300 per cent of boiler rating continuously with either fuel. It was brought out by the Babcock & Wilcox Company.

Fig. 6 shows a combination of gas burner and mechanical atomizing oil burner introduced by the Peabody Engineering Corporation. Plants at Long Beach, Seal Beach, Los Angeles, and Pasadena are using this arrangement. It meets the requirements of group II

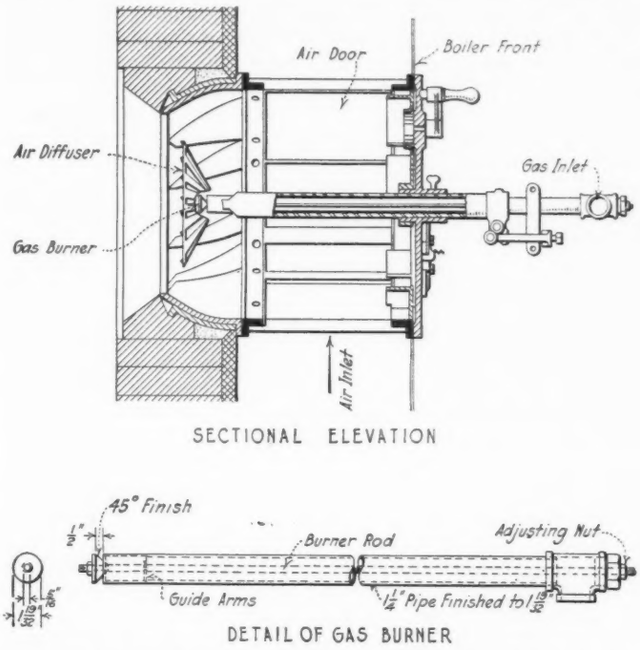

FIG. 7 METHOD OF INSTALLING AN EASILY CONSTRUCTED GAS BURNER IN THE PLACE OF A MECHANICAL ATOMIZING OIL BURNER

as to efficiency and capacity, and particularly as to the ease with which a change in fuel can be made. It is interesting to note in passing that pulverized coal has been burned recently with this equipment.

The requirements enumerated in group II are the hardest to meet. Any combination which will fulfill them will easily meet those of groups I and III.

Fig. 7 shows a method of installing an easily constructed gas burner in the place of a mechanical atomizing oil burner. This, like that shown in Fig. 1, is not really a combination oil and gas burner. It will fulfill successfully only the requirements of group III. This arrangement has been used in a Texas plant.

In the designing of a furnace for handling oil and gas the requirements for oil are the determining factors. Any furnace that is rightly proportioned for oil will also handle gas successfully. Any furnace constructed to withstand for a reasonable time the hard service imposed by oil burners will stand up indefinitely where gas is burned. The majority opinion of designing engineers today seems to be that no unprotected refractory can endure for long where very high boiler ratings are developed with mechanical atomizing oil burners. As a result, practically all of the plants recently designed or being designed to meet these conditions, protect the furnace with air cooling, water screens, or radiant superheaters. This is particularly true where air preheaters are used.

In designing combined oil- and gas-burning furnaces there is apt to be a tendency to select equipment having a low first cost. This invariably proves to be false economy. An improvement of a fraction of a per cent in boiler-room efficiency will soon pay for the most expensive gas or oil burner. Also the loss of the use of a boiler to make burner repairs will offset any saving made by installing a cheap burner if the latter requires only slightly more maintenance than a good burner. The company with which the author is connected has been burning gas and oil in combination for twelve years, and with this experience it has found that the best burners, regardless of cost, are the cheapest.

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Education and Training of Apprentices on the Pacific Coast

By PAUL ELIEL,[1] BERKELEY, CAL.

THE entire Pacific Coast presents a rather unique industrial situation which must be given most serious consideration in connection with any examination of training for industry in this area. Manufacturing of all types has been comparatively slow to develop here due to a variety of causes. The absence of coal has militated against the development of any basic iron and steel industry, although this difficulty has to some extent recently been met through the extensive developments of coal and iron properties in Utah, which ship their pig iron to Pacific Coast plants for conversion and rolling. The predominantly agricultural character of the entire West has also tended to give to the area an economic tone chiefly associated with an agricultural background, and the development has been very extensive along the lines of wholesaling and jobbing with but slight attention to the manufacturing requirements of agricultural communities.

While there have been at various times in the past rather extensive manufacturing developments, particularly along the lines of shoe manufacturing, woolen mills, and the manufacturing of mining machinery, these plants have in the course of time gravitated to the larger Eastern centers through combinations of labor difficulties, shortages of skilled help, and similar factors. There has, of course, been no absence of fuels, particularly in California, since the extensive opening of the oil fields, and the simultaneous development of hydroelectric properties has made possible the delivery of power at reasonable rates.

The fact remains, however, that even today with some eight million persons naturally tributary to the Pacific Coast slope, manufacturing, differentiated from jobbing, really is only in its infancy, and but few plants of any size are located in the three Pacific Coast states.

Other features which have to some extent militated against the development of a progressive and forward-looking training program have been the presence in our school laws of part-time education acts, which in California, for example, require all children to attend school up to the age of 16, and also require five hours of school attendance per week between the ages of 16 and 18. With these several handicaps, such enterprises as are already established on the Coast are, in general, just beginning to think about the problems of trade training.

A very large number of inquiries, sent out in order to secure information as a basis for this paper, disclose the fact that with one notable exception there is not a single industrial establishment on the Coast at the present time with more than a haphazard and rudimentary apprentice-training program.

Other agencies, however, have been giving consideration to this problem with varying degrees of success. All of the larger communities in the state of California with the exception of San Francisco have taken advantage of the provisions of the so-called Smith-Hughes Act and have developed extensive courses of vocational education, of which more will be said below.

In addition, there are privately endowed trade schools in the Coast area which have devoted considerable attention to the training problem.

Finally, there is at least one notable contribution to the problem of training for industry which has been undertaken by a purely private organization, namely, the work done by the Industrial Association of San Francisco.

Specialized Grade Schools Have Limited Field

Returning now to these several public and semi-public agencies, two or three important features must be considered in attempting to measure their success in meeting the problems of industry. Careful investigation has disclosed that in the industrial processes which require considerable specialized knowledge and information in addition to the ordinary requirements of manual dexterity, the vocational-education work in trade or polytechnic school on the Western Coast has, in general, broken down owing to the failure of the school authorities to properly correlate the problems of simulation of actual conditions in industry and the related subjects necessary for reasonable rounded knowledge of the craft in question.

Plants which make an effort from time to time to secure apprentices from the vocational departments of the public schools are critical of the training which these applicants have received in the so-called vocational courses. One industrial executive employing a large number of machinists has stated that all of the young men coming to his establishment from vocational departments of public schools are totally lacking in the most rudimentary knowledge of the fundamentals of drafting, shop mathematics, and similar related subjects.

On the other hand, those schools which seem to have laid particular emphasis upon the less skilled trades have proved eminently successful; for example, the Los Angeles Public School Department through its Vocational Training Division has developed an extensive school program for power-machine operators. Some of the clothing manufacturers of Los Angeles rely very largely on the output of this school for recruiting their ranks, and at the present time about 600 power-machine operators are being developed each year in Los Angeles. Those closely in touch with the situation, however, criticize the power-machine school on the ground that it provides a source of supply from which these concerns can secure skilled operatives at very low wage rates.

The public schools of Los Angeles are also offering vocational courses in some of the building trades, chiefly bricklaying, plastering, and tile setting. Here again the difficulties of attempting to develop through a purely school course all of the craft skill and knowledge necessary for the production of competent mechanics have been recognized, and these courses are only short-time intensive courses designed to give to the entrant to the trade rudimentary knowledge of the more elementary applications of the tools and materials with which he will come in contact on the work itself.

Of the purely vocational schools, the work done at the Benson School in Portland is undoubtedly the best of any of the public or private efforts on the Coast. This school has a series of excellently equipped shops in which a considerable amount of actual work for use is carried on. This school has definitely recognized the necessity for more definite contact with shop problems than is customarily found in vocational schools, and actually requires at least 2400 hours of shop work before graduation. In its vocational courses, which comprise blacksmithing, patternmaking, machine-shop practice, foundry, tool making, cabinet making, carpentry, plumbing, sheet-metal work, electric work, gas-engine practice, and the printing trades, one-quarter of the student's time is devoted to drawing and applied sciences, one-quarter to mathematics, English, and civics, and one-half to work in the shop.

Even here, however, with the most intensive effort on the part of the school authorities to create a practical atmosphere, the graduate of the school after three or four years of instruction, depending upon the nature of the course taken, is certainly not as well equipped as the apprentice in a plant carrying on a carefully-thought-out vocational-training program.

The Lick Wilmerding School in San Francisco has recently made a careful survey of trade-training programs and is about to inaugurate a plan for coöperative relations with industrial concerns looking toward the establishment of the work-study plan under which the shop experience will be gained in the plant while the school will largely devote its attention to related subjects.

Summarizing the vocational effort outside actual industry,

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[1] Director of Industrial Relations Department, Industrial Association of San Francisco. Assoc. A.S.M.E.

For presentation at the Spring Meeting, San Francisco, Cal., June 28 to July 1, 1926, of The American Society of Mechanical Engineers. All papers are subject to revision.

it could probably be said that only in semi-skilled trades has the vocational school proved a success.

WORK AT THE CATERPILLAR TRACTOR COMPANY'S PLANT

Turning now to the one example on the Coast of a complete trade-training program within an industry, the work done at the plant of the Caterpillar Tractor Company is of an outstanding character. Apprentices are required to sign an actual form of indenture which, among other things, provides that he must successfully complete approximately 9000 working hours in the shop and must have obtained practical experience of a satisfactory character in the several operating divisions of the plant. The problem in this plant is made simpler owing to the fact that while they are working on a very high production schedule for the West, no progressive or string operations are undertaken outside of the actual assembly floors, although the materials are carefully routed through the plant from process to process.

The most interesting aspect of the work done in this shop relates to the effort made by the supervisor of training to develop a flexible system which will provide for the individual skills, aptitudes, and requirements of the various apprentices. For example, there is absolutely no definite schedule of progression of the apprentices from tool to tool in the shop, but merely the general requirement that he shall put in approximately two and one-half years in the production departments and one and one-half years in the so-called auxiliary department. This latter department comprises a number of subdivisions, the most important of which is the toolroom, where the apprentice is required to spend a considerable time on lathes, millers, and bench work. Also included in the auxiliary departmental work is the heat-treating department, the general inspection department of the plant, and the service shop.

Divisions in the production department are the tool crib, drilling department, hand milling, rough grinding, screw machine, Jones & Lamson turret, engine lathe, toolroom, grinding, Warner & Swasey turret, Bullard turret, and assembly department. In connection with all of this work it must be borne in mind again that there is no effort to route men through it in accordance with any predetermined plan, but the apprentice supervisor makes an effort to watch the individual requirements of each of the apprentices and to so place him that he will progress as rapidly as possible through the several phases of the work, with such assigning from tool group to tool group as may appear to be the most desirable to suit the individual need.

WORK IN RELATED SUBJECTS

In addition, there is an extensive course offered in shop mathematics, to which the apprentice is required to devote at least five hours per week of his time. Here again an effort is made to provide the utmost flexibility, depending upon the actual knowledge of the apprentice prior to his entrance into the shop and on his natural aptitude. No apprentice is accepted who is not able to perform the fundamental arithmetical operations relating to fractions and decimals. Beyond this point the plant school offers a complete schedule of fundamentals, which include such pure mathematical processes as involution and evolution; geometry and mensuration; elementary trigonometry; elementary mathematics of pulleys and gearing; the nomenclature, types, and uses of threads, gears, and lead screws, graduated dials, cutting speeds and fits, tapers, spur, bevel, and worm gears; the use of the sine bar; and elementary shop physics and mechanics.

In addition, the apprentice is required to devote a considerable amount of his time to mechanical drawing, depending upon his individual skill and aptitude. No effort is made to develop mechanical draftsmen, but only the ability to make a representative and understandable shop drawing and to interpret any blueprint which may come to the mechanic's attention. Among the elements covered in this phase of the work are geometrical construction, projection, auxiliary and revolved views, sections, shop sketching, working drawings, and tool design.

In addition, there are a number of shop talks given during the course of the apprentice's training covering general problems in the shop and such important related subjects as cutting tools and their elements, cutting compounds and lubricants, fundamentals of the several main classes of machine tools, gage principles and methods, shop systems and organization problems, and general topics relating to safety, shop habits and operation, etc.

The plant of the Caterpillar Tractor Company is operating on a modified Taylor-system basis, and all jobs in the shop are controlled by standard times, determined through time study. During the apprentice's tour through the various tool groups he is required to work upon the same materials and parts as come to the mechanic in the same tool division, and the apprentice's actual time on these parts is scheduled against standard time for this same operation.

INCENTIVE METHOD EMPLOYED

Monthly records are kept for each apprentice, and a monthly average on all the operations on which he is engaged is compared to standard time for these same operations. Each month the apprentice making the best record, as compared to standard times, is for the following month allowed an increase in his wages equivalent to the increased wage which he would normally receive during the next half-yearly term of his training.

In this establishment the apprentice begins work at approximately thirty per cent of the standard journeyman machinist's wage, and his wages increase approximately five per cent of such standard wage for each six months of his term of apprenticeship.

The company provides the apprentice at the beginning of his term with a set of tools valued slightly in excess of $16, for which the apprentice is required to pay, but the cost of these is refunded to him when he has satisfactorily completed his first two years of training, the tools then becoming his personal property. At the beginning of his third year of training he is provided with a set of more advanced tools for which he must also pay, but the cost thereof is refunded to him by the company at the termination of his apprentice course, at which time these tools also become his property.

A regular diploma certifying that the apprentice has completed the course is offered at the end of the four-year program, and a certificate is offered at the end of three years of training, at which time the apprentice is permitted to voluntarily withdraw from his indenture if he so desires.

The supervisor of training has not employed any special technique for examining applicants, but relies almost entirely upon personal interview. He will not, however, as already mentioned, accept as apprentices boys who do not possess a knowledge of the rudimentary mathematical operations involved in the use of fractions and decimals.

The Caterpillar Tractor Company, which employs about 500 men at its San Leandro plant, attempts to maintain a group of about 25 apprentices at all times in its shops.

TRADE SCHOOLS OF INDUSTRIAL ASSOCIATION OF SAN FRANCISCO

Mention has already been made of the work which is being done by the Industrial Association of San Francisco in connection with training for industry. While most of the effort of this organization has been devoted to the application of training methods to the building trades, it now has in operation a very successful foundry school, which is generally considered to be one of the most outstanding developments in foundry practice in the country.

Since the association has no actual plant at its disposal, it has approached the problem of trade training from a special angle. An analysis of the attitude of employers to the hiring of apprentices has indicated that, in general, they are not disposed to look favorably upon apprentices because of the actual difficulties and the actual liabilities involved by the employment of these absolutely unskilled men. The association therefore decided to attempt to meet this difficulty through the provision of groups of short-time intensive-training courses. The object of these courses is to provide merely a sufficient grasp of the rudimentary operations of the trade in order to acquaint the apprentice with enough of the actual craft skill so that upon the termination of this course he may be employed and actually earn his way from the start.

Intensive courses of this nature have been developed for plasterers (plain and ornamental), plumbers, bricklayers, tile setters, painters, decorators and paper hangers, structural-steel men, electricians, and molders. In all of these trades with the exception of that of molding, the Association has developed within a large loft-type building as complete a simulation of actual job conditions as possible.

Apprentices, carefully chosen as a result of tests and interviews, attend this school for varying periods but usually for ten weeks, eight hours a day and 44 hours a week. Commencing with the elementary tools required in the trade and the manipulation of these tools and the materials, the apprentice is developed through a series of progressive problems touching on all of the fundamental phases of his work.

As an example of the method employed, the plasterers' school may be used as an illustration. Twenty men, between the ages of 18 and 26, were chosen for the initial class in this school. The average period of instruction was about eleven weeks. All of the tools and materials were provided for the apprentice and he was not paid during his period of attendance, nor was he charged any tuition for the course. In connection with the rough phases of the work ordinarily embraced in the terms of "brown coating and scratching," emphasis was placed on the acquisition of the proper bodily motions in applying the materials, and as much emphasis as possible was placed upon developing speed. In connection with finishing, however, the entire emphasis was on quality.

At the end of the initial instruction period the apprentice, who had been guaranteed a position before he entered the school, was placed with a plastering contractor at a rate of $4 per day. Every effort was made to follow up the apprentice in order to guarantee that he was making satisfactory progress, that he was not being taken advantage of by his employer, and that he was being given an opportunity to gain experience upon all classes of work.

At the end of approximately a year on the job he was invited to return to the school for night instruction in ornamental plastering. Here the problem was in many ways a simpler one—the knowledge of the use of the tools had been acquired as well as the nature of the materials with which he was required to work, and although the tools required in the ornamental work are of a different sort than those required in plain plastering, the actual variety of problems is more limited.

No set time was required for the apprentice to remain within the school, but he was offered an opportunity to learn to run cornices, to make his own molds, to take off the architectural drawings the details of cornices preliminary to the preparing of the mold, and the putting in of miters. Upon the completion of such work in ordinary plaster the apprentice was transferred to the more difficult problems of the application of cement to ornamental work. Finally at the completion of his work he was required to take an examination involving the actual installation of an intricate problem from the architect's drawing to the completed product, with emphasis upon quality but also a limitation upon the amount of time allowed which closely approximated expected production of a skilled man.

This in general has comprised the fundamentals of the association's method of meeting the trade-training problem, namely, a short-time intensive course followed by night work involving both manual and related steps. In approximately three years and a half the association has had in excess of 1200 men in its several schools. The definite proof as to the applicability of this method lies in the work which these apprentices have done on various building projects in San Francisco during this time. A number of these men have been graduated to positions of foremen and superintendents, and others are actually engaged as journeymen upon the more difficult and intricate phases of their craft.

In connection with any special program it is vitally necessary that there be an extraordinarily careful follow-up and check upon the progress of the apprentice in order to guarantee that he will obtain training on all fundamental features of his craft and in order to protect him against exploitation by his employer.

The securing of proper apprenticeship committees in the several crafts to whom training problems can be referred and in whom the employers in the craft have confidence is vitally necessary in the carrying out of such a program. In this connection it is customary for the Industrial Association to set up, in coöperation with employers, definite understandings covering all fundamental conditions of the apprentice-training program providing for regular advancement and requiring the apprentice to continue his school instruction in order to remain at work in the trade, etc.

At the present time the association is not conducting any training courses for new entrants to any of the trades, but is only carrying on the advanced work involving not only the education of the apprentices but also the education of the trade itself to the applications and implications of an apprentice-training program. All of the present work is being carried on at night schools with employers' committees actively engaged in attempting to develop the fundamentals of each craft's content.

The entire technique and work of the Industrial Association affords an interesting example of the type of work which can be done in connection with a group of employers, none of whom could undertake an apprentice-training program individually, but who through a community of effort and a common interest in the importance of the apprentice problem are able to develop constructive and valuable training programs.

Growth of University Extension Training of Non-College Type for the Industries of the West

By JOHN L. KERCHEN,[1] BERKELEY, CAL.

IT IS THE intent of this paper to present for consideration the nature, scope, growth, need, and method of university extension courses that are of less than college grade and that have for their chief purpose the training of persons engaged in non-professional or semi-professional pursuits.

Courses of this type have come into being largely in response to a demand from workers in industry who have felt the need of a more specially adjusted type of education, a type that will more closely aid and supplement the occupational needs of the worker and his job. Persons seeking training of this type rarely do so in order to prepare for college or for further education—it is designed to enhance the needs of those whose choice of a vocation has already been made; who have discovered that "earning and learning" are closely allied, and in order to earn more they must learn more. It is an education that is more practical than theoretical; more a training for hands than an education for heads, though it is not meant that any inference is to be drawn from this that trained hands and educated heads are not complementary.

This study is based upon the observations, facts, and findings of the Extension Division of the University of California at Berkeley, including the work of the various branches of the Extension Division located in different parts of the state. It was hoped that the work of extension divisions of other western universities could also be discussed here, but in some cases information was not obtainable and in others it was so slight as to be negligible for use in this paper. However, the facts and figures quoted are believed to be generally characteristic.

The Extension Division of the University of California offers courses of non-college type both by class instruction and correspondence methods. For convenience of comparison the class enrolments at five-year intervals, beginning with the school year 1914–15, and closing with the school year 1924–25, are listed in Table 1. It should be noted that these figures are not cumulative; those in each column represent the enrolments for that particular year only. The blank spaces indicate that there were no enrolments for the year in question, or that the course was not offered at the time indicated. The lists in Tables 1 and 2, both class and correspondence, are chosen, first, because they are predominently of non-college type, and, second, because very few of them are given any credit, either of matriculation or college grade.

It will be noted from Table 1 that courses of this type increased from 67 in 1914–15, to 518 in the year 1919–20, and to 2041 during 1924–25.

It should be noted that a marked decrease shown in the enrolment for a certain type of course, for example, machine-shop and auto-shop courses, is frequently due to the fact that these courses have been taken over by the local high school of the community in which they were given. It is not the policy of the University Extension to offer competing courses in cases where they are well cared for by the local school authorities.

The list of correspondence enrolments given in Table 2 covers practically the same field of training as the class courses given in Table 1. The courses are of non-college type, and, according to the record of "intentions" expressed by those taking them, the chief reason advanced was that of better preparation for the work in which the students were engaged. While the increase here is marked, it is not decidedly so, as is indicated in the advance made in classroom instruction. It is more likely a normal increase that

TABLE 1 CLASS ENROLMENTS AT FIVE-YEAR INTERVALS

	1914–15	1919–20	1924–25
Architecture			
Architectural Drawing	8	..	..
Introduction to Architecture	..	..	17
Blueprint Reading			
Blueprint Reading 1	..	..	132
Blueprint Reading for Metal Trades	..	..	15
Blueprint Reading for Building Trades	..	..	54
Estimating for Building Trades 5	..	..	30
Electricity			
Direct-Current Electricity 1	59	16	132
Alternating-Current Electricity 2	..	132	63
Direct-Current Electricity 3	..	..	67
Practical Applications of Alternating Current	..	98	57
Telephone Electricity	..	..	29
Wireless Telegraphy	..	13	..
Engineering			
Modern Home Construction	..	..	68
Strength of Materials	..	..	27
Safety Practice in Industry	..	..	10
Maritime Engineering			
Diesel Engines	..	..	138
Diesel-Engine Design	..	..	32
Mathematics			
Algebra A	..	16	34
Advanced Algebra 1	..	..	18
Plane Geometry 2	..	26	24
Plane Geometry 7	..	..	20
Plane Trigonometry	..	19	14
Shop Arithmetic	..	9	12
Mechanics			
Automobile Construction	..	82	..
Machine Shop	..	132	..
Automobile Shop 6	..	154	14
Automobile Shop 8	..	..	16
Reinforced Concrete	..	33	..
Reinforced Concrete 11	..	..	26
Reinforced Concrete 12	..	11	21
Engineering Mechanics	..	8	15
Gasoline Automobiles	..	28	114
Induction Relays	..	..	29
Lubrication	..	..	137
Combustion Heat	..	..	56
Casinghead Gas	..	..	236
Petroleum Engineering			
Petroleum Production and Utilization	..	..	..
Petroleum Refining	..	..	564
Petroleum Field Technology	..	..	54
Fractional Distillation	..	..	54
Radio			
Radio 7	..	..	147
Radio 8	..	..	142
Radio 10	..	..	14
Shipping			
Merchant Vessels	..	..	27
Shipping Practice	..	..	78
Totals	67	518	2041

TABLE 2 CORRESPONDENCE-COURSE ENROLMENTS

	1914–15	1919–20	1924–25
Electrical Engineering			
Direct-Current Electricity	18	89	52
Alternating-Current Electricity	5	40	23
Electricity 3	1	..	..
Electricity and Magnetism	..	..	9
Elementary Radio	..	..	73
Theory and Operation of Direct-Current Machinery	..	..	7
Electricity for Rural Use	..	6	6
Engineering Drawing			
Shop Sketching 21	..	9	16
Instrumental Drawing C-D	20	84	69
Mechanical Drawing E-F	4	18	4
Mechanical Drawing G	2	3	6
Descriptive Geometry 3	1	9	12
Heat Power Engineering			
Heat Power Engineering 1	..	..	3
Hydraulics			
Hydraulics 1	..	..	2
Map Reading			
Map Reading and Interpretation	..	..	6
Materials of Engineering Construction			
Surveying 1	..	..	22
Materials of Engineering Construction	..	..	11
Elementary Mathematics			
Arithmetic 1	..	13	45
Shop Arithmetic 50	30	48	54
Elementary Algebra	57	104	170
Elementary Algebra 2	11	30	50
Plane and Solid Geometry	12	51	67
Trigonometry	21	39	48
Mechanical Engineering			
Essentials of Mechanics 12	..	43	15
The Gasoline Automobile	..	41	46
Technical Mathematics	..	..	10
Total	182	627	826

[1] Director, Workers' Education Extension Division, University of California.

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might be expected from a going concern which is serving a growing population.

General Courses of Non-College Type

In addition to the two lists that have been given there are a great number of courses of non-college type that are only slightly removed from immediate contact with industry. For example, there may be selected at random from a large list with heavy enrolments such courses as:

Business English	Elementary Accounting
Advertising	Salesmanship
Commercial Art	Oral Expression
Commercial Lettering	Bookkeeping
Business Practice	Business Administration
Commercial Law	Money and Banking
Principles of Economics	Foremanship
Business Law	Journalism

Whether such studies as these function in terms of immediate service to industry depends largely upon the use made of them by the persons taking them and the aim which they had in view. It is the opinion of the author that practically all of them serve industry most effectually. A more strictly practical and vocational study cannot be imagined than a correct use of written and spoken English. The possession of this achievement has helped many a worker to a job, and its absence has wrecked numerous otherwise excellent opportunities to secure or hold positions.

One of the best indications that studies of this type are believed by managers of industry to be of extreme significance is the fact that nearly forty per cent of the group class courses for employees given by the employers and paid for by the management of different industries are included in the above group. The demand for this non-college, semi-cultural type of training shows the most rapid rate of increase of any of our courses. They increase the interest of the worker in the welfare of the concern as well as in the job. They develop a more satisfactory type of employee, and definitely create a better and finer morale on his part.

Workers' Education of the Extension Division

The Extension Division of the University of California in cooperation with the State Federation of Labor of California carries on an educational enterprise which is unique in the partnership of learning and labor. In this work there is employed a full-time director who gives his whole time to the organization of workers' education for the Extension Division. This education in the very best sense is for, by, and of workers in the various industries. Obviously the studies chosen are of non-college type. This department is organized for the sole purpose of stimulating an active interest in education on the part of workers and to meet this resultant demand for education and training, whatever the nature of it may be. The purpose is to reach workers and only workers, and, of course, no discrimination is made between the organized and unorganized. The workers choose the course, the instructor, and the time, place, and manner of meeting.

Because of the democratic nature of this procedure the experiment is probably a very sensitive index to whatever desire and demand there is in the rank and file of labor and, in addition, to the nature of that demand.

During the past four years some sixty classes for working groups have been organized on the above-mentioned basis in different parts of the state. The attendance has exceeded two thousand. As to the nature of the classes chosen, one-fourth of them have been vocational. Carpenters choose blueprint reading and estimating; electricians take elementary electricity, and engineers who see the likelihood of a transition from steam to gas, take Diesel.

Three-fourths of the courses chosen by these working groups lie outside of the field of any special vocation. They are courses concerned with the problems of the worker that arise from his status as an industrial citizen. These courses include English and speechmaking (most labor representatives are potential orators), industrial history, labor problems, labor economics, modern industrialism, the control of wages, etc. On the whole, these men choose from the economic and social sciences, and while they enjoy a labor slant, their interest is little different from that of the cross-section of any industrial population.

The Methods of Class Organization

The "one best method" of organizing a class and that will at the same time apply to nearly all classes, does not exist. The method in each group of cases, and frequently in each individual case, depends upon the contingencies that enter into the problem.

The following publicity agencies are used in making the Extension's desires known to the public:

1 *The Newspaper.* For purposes of a general announcement there is no more potent agent in giving it wide circulation than the columns of the daily newspaper.

2 *Class Schedules and Bulletins.* These are especially useful in serving a patronage that has formed the habit of taking extension work as a regular activity.

3 *Personal and Circular Letters.* A large percentage of these are very productive. They frequently lead to personal negotiations that conclude with courses.

4 *Posters.* These are of questionable value. They are attractive, but the extent to which they induce persons to enter classes is debatable.

5 *The Personal Interview.* In cases where there is a chance for the organization of a group class for some definite concern, this is the very best form of group-class organization. In such cases there is usually one individual or a committee to convince, and the personal equation is the most vital.

Instructors

There is a definite policy on the part of the Extension Division in selecting instructors for this type of education. They are chosen from all walks of life and from every part of the state. Some of them are academically trained with college degrees, but many of them are not. In cases where a practical knowledge of a trade is the necessary requisite, then such qualifications are sought. In general it has been found that those who have had both technical and trade training, and who also have vigor, vim, and personality, make the best instructors.

Fees

The fee charged for nearly all kinds of instruction is $6 per student for fifteen hours of instruction. This applies to both class and correspondence courses.

Conclusion

In conclusion, it would seem that—

1 There is a steadily increasing demand for instruction and training of non-college type that correlates most closely with the demands of industry.

2 It is quite evident that in courses of this type the policy should be to trust the demands of industry in shaping courses rather than to rest upon the practice of custom and tradition.

3 Instructors should be chosen who possess first-hand experience in the industry to which they impart instruction.

After all, the industry is the thing. The educational tail should not be permitted to wag the industrial dog. At its best, education little more than supplements the industry of which it is the willing servant.

Synopses of Other Spring Meeting Papers

THE papers abstracted below are being printed in full in pamphlet form for the Spring Meeting of The American Society of Mechanical Engineers. They may be secured by filling out either the blank on page 692 of this issue or that published in the May 7 issue of the A.S.M.E. NEWS and mailing it to the office of the Society. The remainder of the papers preprinted for the meeting are being distributed in this special Supplement to the June, 1926, issue of MECHANICAL ENGINEERING. The tentative program for the Spring Meeting appears on page 694 of this issue.

Fluid Flow in Pipes of Annular Cross-Section

By D. H. ATHERTON

Assistant Professor of Mechanical Engineering, University of California, Berkeley, Cal. Assoc-Mem. A.S.M.E.

THE object of the investigations reported in this paper was to determine the actual values of the friction coefficients for the flow of air, oil, and water through pipes of annular cross-section. The apparatus and method of testing are described and the data and results of the tests are given in graphic and tabular form. It appears that the coefficient of friction corresponding to any given turbulence factor for both turbulent and viscous flow has a value for pipes of annular cross-section slightly higher than for pipes of circular cross-section when determined by the equivalent-diameter formula.

Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines

By C. W. CUTLER

Industrial Engineering Department, General Electric Co., Schenectady, N. Y.

THIS paper forms a basis for the design of flywheels for engine-driven generators operating in parallel, the present rules simple enough for commercial design applying only in the case of operation against an infinite system. The paper therefore develops a method whereby the power exchange, torque variations, and other phenomena can be accurately obtained with practically no greater effort than with the present approximate rule. The general solution for two engine-driven generators by means of a nomographic chart is given in an appendix, which also explains the method of constructing the chart.

The Termination of Charcoal Tests

By F. L. KALLAM

Superintendent, Mutual Gasoline Co., Los Angeles, Cal. Jun. A.S.M.E.

ONE of the most important features of testing natural gas for gasoline content by means of activated charcoal is the knowledge of when to terminate the test. This paper deals with a method by which the maximum gasoline content may be determined without danger of under- or over-saturating the charcoal when even the approximate content of the gas is unknown. It points out that the correct termination point is determined from the temperature rises and falls in the charcoal due to the adsorption and displacements of the various hydrocarbons. The modifying effect of the condensing phase of the problem is also discussed and conclusions drawn.

Transmission of Power on Oil-Engine Locomotives

By ALPHONSE I. LIPETZ

Consulting Engineer, American Locomotive Co., Schenectady, N. Y. Mem. A.S.M.E.

POWER transmission on oil-engine locomotives depends upon the type of the oil engine for the locomotive, and upon the conditions under which the locomotive is going to run.

This paper pertains to the transmission of power only, and gives a classification of power transmissions in chronological order of their appearance in the art.

Class A comprises full-power elastic-fluid transmissions in which the total output of the oil-engine is transfered into elastic-fluid energy, which is, in turn, utilized for the propulsion of the locomotive. The efficiency of such a transmission is the product of the two separate efficiencies of the generation and utilization of energy. Various types of electric, hydraulic, pneumatic, compressed-steam, aero-steam, and compressed-exhaust-gas transmission are described and the results so far obtained are given. As regards illustrations, only such are included in the paper as have not recently been published in American journals

Class B consists of differential elastic-fluid transmissions in which the power from the oil engine is transferred directly to the driving wheels at top speeds of the locomotive with a very high efficiency, and partly directly and partly indirectly at all intermediate speeds. The theory of such transmissions is expounded, and formulas for torques, speeds, and efficiencies are derived. Examples of electric, hydraulic, and pneumatic transmissions of this type are described and results so far obtained are given.

Class C pertains to mechanical (gear-clutch) and direct transmissions. Locomotives of these types are described and performance results given.

The drawing of conclusions as to the possible fields of application of various types of transmissions is postponed until the questions of the types of oil engines and different conditions of locomotive performance on railroads are discussed in a separate paper. That part of the paper which contains the discussion of the Class C transmissions, together with a brief presentation of the essential parts of sections devoted to Class A and Class C transmissions, will be printed in pamphlet form for presentation at the San Francisco meeting. The complete paper is to be published later in MECHANICAL ENGINEERING.

Aspects of Steam Power in Relation to a Hydro Supply

By A. H. MARKWART

Vice-President in Charge of Engineering, Pacific Gas and Electric Company, San Francisco, Cal.

STEAM power, in a regional power system having a hydro supply as its basis, either because it was started that way or because fuel may for a time have been costly, has greater significance than is generally conceded. Steam power becomes increasingly important as hydro sources become more remote and costly of development; as the annual load factor may tend to lower; as the public may demand higher standards of service; as those manufacturing industries requiring greater continuity of service may grow; as hydro generating and transmission units may increase in capacity; as stream-flow plants without storage regulation become more numerous; and as cyclic changes in water run-off, becoming revealed, may indicate hydro deficiency.

Briefly, steam power is needed

1 To effect the best system economy
2 For stand-by
3 For meeting the seasonal hydro deficiency during the short-water period on non-regulated streams
4 For meeting the dry-year hydro deficiency.

The above phases, together with hydro capacity and cost of power, are broadly discussed in the paper, which is also published on pages 567–571 of this issue.

Speed Changes of Hydraulic Turbines for Sudden Changes of Load

By EARL B. STROWGER and S. LOGAN KERR

Respectively The Niagara Falls Power Company, Niagara Falls, N. Y., and Assistant Hydraulic Engineer, Wm. Cramp & Sons Ship & Engine Building Co., Philadelphia, Pa. Jun. A.S.M.E.

THIS paper shows how the variation in speed of hydraulic turbines due to sudden load changes may be determined by the application of the fundamental principles of water hammer with allowances for variation of turbine efficiency. The methods of determining governor time are noted. The relation of generator flywheel effect to speed variation is established and methods are indicated for the proper selection of these characteristics. Numerical examples are shown illustrating the speed changes for various load changes on a 70,000-hp. hydroelectric unit. The application to practical cases and the accuracy of approximate formulas are discussed.

The following papers, to be presented at the Spring Meeting, will be available in pamphlet form and may be secured without cost by any member of the Society.

Check papers desired and mail form to the Secretary.

Disregard this form if you have already filled out a similar blank published in the A.S.M.E. News for May 7.

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Check Here (X)	Authors and Papers	Date Shipped	By
	Atherton, D. H., Fluid Flow in Pipes of Annular Cross-Section		
	Cutler, C. W., Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines		
	Kallam, F. L., Jr., The Termination of Charcoal Tests		
	Lipetz, A. I., Transmission of Power on Oil-Engine Locomotives		
	Markwart, A. H., Aspects of Steam Power in Relation to a Hydro Supply		
	Strowger, E. B., and Kerr, S. Logan, Speed Changes of Hydraulic Turbines for Sudden Changes of Load		

To the Secretary, A.S.M.E., 29 West 39th Street, New York City. Date .....

Please send copies of the papers checked above to

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Contributors to this Supplement

B. N. Broido

B. N. Broido was born in Wilna, Russia. His engineering education was obtained in Germany, and he was graduated in 1903 from Frederick's Polytechnic with a degree in mechanical engineering, and for the next two years was an instructor at that institution. From 1905 to 1911 he was connected with the W. Schmidt Machine Manufacturing Co. He next became connected with the Seiffert Co. in Berlin, where he designed and tested different types of stokers. In 1913 and 1914 he was with the Egestorf Manufacturing Co., engaged in the problem of making Stirling boilers to fit German conditions.

Mr. Broido came to this country in 1914 and took a post-graduate course in the College of the City of New York and Columbia University. Later he became connected with the Roessler & Hasslacher Chemical Co., for whom he designed power plants. In 1917 he was engaged by the Philadelphia & Reading Co. to design a power and creosoting plant. At the close of 1917 he became connected with the Superheater Co. as designing engineer and is still with this company as a consulting engineer, also in charge of engineering of the industrial department. In the past seven years Mr. Broido has filed over fifty applications in this country and abroad for patents on boilers, superheaters, economizers, etc.

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J. L. Kerchen

J. L. Kerchen is director of workers' education for the University of California Extension Division. During early life he worked as a tradesman in wood and metal. Later he went to a normal school and upon being graduated taught school in Spokane, Wash. Subsequently he attended Stout and Bradley Polytechnic Institutes, and was then for two years in Chicago University where he specialized in industrial and vocational education. From 1911 to 1916 he was director of vocational education at Portland, Ore., and the following year received his A.B. from the University of California, majoring in education and economics. In 1919 he received his M.A. from the same institution. He taught for two years in the polytechnic high school of Oakland and for two summer sessions taught the theory and practice of teaching for trades teachers in the University of California. He has held his present position since 1921.

J. C. Martin, Jr., has been very closely associated with the use of fuel oil on railways for fifteen years as vice-president and general manager of the Aetna Combustion Co. This concern owns and controls the present system of firing oil in locomotives, which is the one in use today on practically all oil-burning railways of the United States, Canada, and Mexico. The development, refinement, and extended use of this system have been entirely under his jurisdiction. He is also a consulting engineer in San Francisco, California, devoting particular attention to problems of combustion and the utilization of petroleum hydrocarbons and refractories in oil-refinery practice, as well as on railways.

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J. G. Rollow

J. Grady Rollow was graduated from the University of Tennessee in 1905. His first employment was with the Stirling Co., Barberton, Ohio, which concern was purchased by the Babcock & Wilcox Co. in 1907. He spent one year with the International Steam Pump Co. and then returned to the Babcock & Wilcox Co. in September, 1909. From 1913 to 1917 Mr. Rollow was with the Southern California Edison Co., resigning to enter the engineering department of E. I. du Pont de Nemours Co., where he remained for three years. From 1920 to 1924 he was consulting engineer with the Los Angeles Gas & Electric Corporation, and since February of the latter year has been in charge of electrical operation and construction for that concern.

Besides being a member of the A.S.M.E. he is an associate of the A.I.E.E. He is vice-chairman of the technical section of the Pacific Coast Electrical Association, and a member of the Pacific Coast Gas Association.

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H. A. Barre

H. A. Barre was graduated from the University of California in 1897. He has been very closely identified with the progress of steam, water-power and electrical - engineering work of the public utilities in California continuously since that time. His former association was with the Pacific Power & Light Co. When that company was consolidated with the Southern California Edison Co., Mr. Barre went into the new organization as executive engineer, which position he occupies. He is a member of the A.S.M.E. and the A.I.E.E.

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Paul Eliel was graduated in 1913 from the University of Chicago, where he specialized in economics and political science. He studied municipal government in England, France, Germany, Belgium, and Holland, and then became special investigator for a number of California cities on municipal problems, particularly in regard to finance and public safety. From 1916 to 1917 he was assistant city manager of San Jose, Cal., and then became connected with the staff of the San Francisco Bureau of Government Research, in charge of public-safety investigations. He was director of this bureau from 1918 to 1921, resigning to become associated with the Industrial Association of San Francisco. Since 1923 he has been director of the Industrial Relations Department of this association.

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Fred Thilenius

Fred Thilenius was graduated from Washington University, St. Louis, in 1912. For several years he was connected with the Missouri Railway Company on special work having to do with construction and testing bridges. He now holds the position of assistant master mechanic of the Southern Division of the Prairie Pipe Line Company.

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P. E. Holt

Pliny E. Holt was born in London, Merrimac County, New Hampshire, son of W. Harrison Holt, the eldest of the four brothers who were active in building up the business that later became the Holt Manufacturing Co. He moved to Ohio in 1879, and to the prairies of Minnesota in 1882. He received his education at the high school of Minneapolis and the University of Minnesota. His connection with the tractor industry began with his work with the Holt Manufacturing Company on February 15, 1896.

From 1896 until 1909, he was connected with the company in various capacities, generally of an engineering nature. During all of this period, he was closely associated with Benjamin Holt, president of the company and its inventive genius, and took a very active and important part in all the experimental

and development work, of which the caterpillar tractor is the product.

In 1905 he organized and became president of The Aurora Engine Company, which was later incorporated in the Holt Manufacturing Company, which supplied the gas engines used in Holt gas tractors. In 1909 he established the Holt Caterpillar Co., of Peoria, Ill.

When war was declared, Mr. Holt went to Washington and was there most of the time until after the armistice was signed. His service in Washington was as chairman of the Board appointed by the Chief of Ordnance to handle the design and production of the "Caterpillar" artillery program.

Mr. Holt is now serving as vice-president of the Caterpillar Tractor Co., which concern recently succeeded the Holt Manufacturing Company and the C. L. Best Tractor Co.

A.S.M.E. Spring Meeting Program

San Francisco, Cal., June 28–July 1, 1926

Monday, June 28

Morning:

Council Meeting, 9:30 A.M.
Conference of Local Sections Delegates, 9:30 A.M.
Meeting of Nominating Committee, 9:30 A.M.–5:30 P.M.
Business Meeting, 11:30 A.M.

Afternoon:

Excursion to Muir Woods, 12:45 P.M.
Alternate Excursions and Shopping Trips for Ladies, 2:00 P.M.

Evening:

Reception and Dance, 8:30 P.M.

Tuesday Morning, June 29

Meeting of Nominating Committee, 9:30 A.M.–5:30 P.M.
Ladies' Shopping Tour, 9:30 A.M.
Simultaneous Sessions, 10:00 A.M.

Petroleum Session

Fluid Flow in Pipes of Annular Cross-Section, D. H. ATHERTON.
Mechanical Engineering in Cracking, Heating, and Cooling of Oil, B. N. BROIDO.
The Termination of Charcoal Tests, F. L. KALLAM.

Industrial Training and Education Session

The Growth of University Extension Training of the Non-College Type for the Industries of the West, JOHN L. KERCHEN.
Education and Training of Apprentices on the Pacific Coast, PAUL ELIEL.

Tuesday Afternoon

Steamer Trip on San Francisco Bay, 12:30 P.M.–9:30 P.M.

Alternate Excursions, 2:00 P.M.
Ladies' Bridge Party, 3:00 P.M.

Wednesday Morning, June 30

Meeting of Nominating Committee, 9:30 A.M.–5:30 P.M.
Simultaneous Sessions, 10:00 A.M.
Excursions for Ladies, 10:30 A.M.

Hydraulic Session

Aspects of Steam Power in Relation to a Hydro Supply, A. H. MARKWART.
Water Power and Steam Power in California Utilities, H. A. BARRE.
Speed Changes of Hydraulic Turbines for Sudden Changes of Load, EARL B. STROWGER and S. LOGAN KERR.

Fuels and Railroad Session

Combined Oil and Gas-Burning Furnaces for Power-Plant Use, J. GRADY ROLLOW.
Fuel Oil for Railways, J. C. MARTIN, JR.
The Development of the Caterpillar Tractor and Its Application to Industry, PLINY E. HOLT.

Oil and Gas Power Session

Transmission of Power on Oil-Engine Locomotives, A. I. LIPETZ.
Oil Engines as a Drive for Pipe-Line Pumps, F. THILENIUS.
Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines, C. W. CUTLER.

Wednesday Afternoon

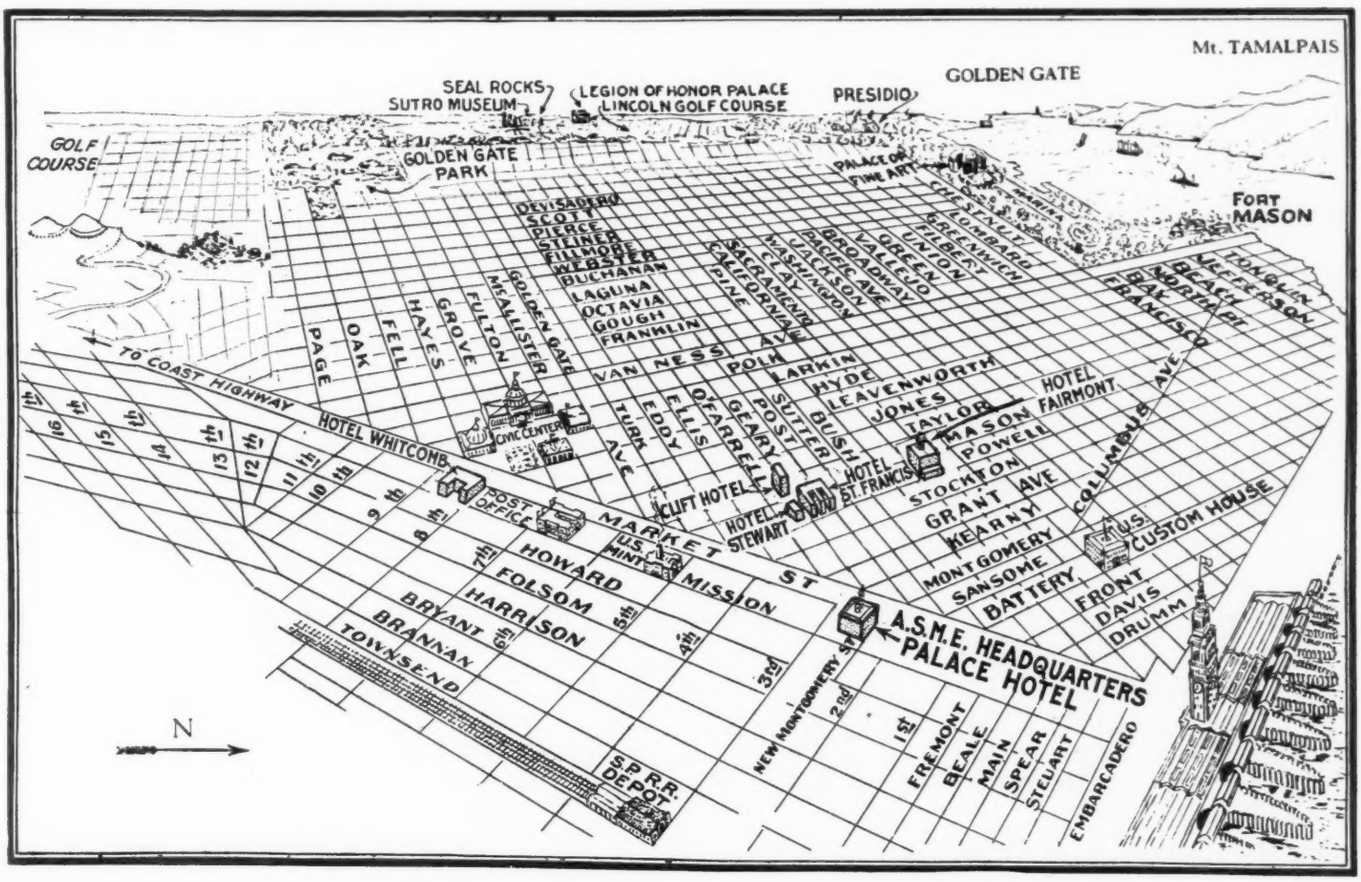
Auto Tour Around San Francisco, 1:45 P.M.
Excursions, 2:00 P.M.
Ladies' Tea at Fairmont Hotel, 4:30 P.M.

Wednesday Evening

Banquet, 7:00 P.M.

Thursday, July 1

Conference on A.S.M.E. Boiler Codes
Excursions.



A Convenient Chart of the City of San Francisco, Showing Location of A.S.M.E. Headquarters and of Many Points of Interest, as Well as of the Hotels Recommended to Those Attending the Spring Meeting